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A

REFERENCE HANDBOOK

OF THE

MEDICAL SCIENCES

EMBRACING THE ENTIRE RANGE OF

SCIENTIFIC AND PRACTICAL MEDICINE

AND

ALLIED SCIENCE

BY VARIOUS WRITERS

ILLUSTRATED BY CHROMOLITHOGRAPHS AND FINE WOOD ENGRAVINGS

EDITED BY ALBERT H. BUCK, M.D.
NEW YORK CITY

VOLUME VI.

NEW YORK
WILLIAM WOOD & COMPANY
56 & 58 LAFAYETTE PLACE

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v

A REFERENCE HANDBOOK

OF THE

MEDICAL SCIENCES.

PRAIRIE ITCH. This is an affection, or rather a group of affections, met with frequently in the northern and western portions of this country, but seldom seen in the Southern States, which has long been, and still is, a subject of much dispute among practitioners in the regions first mentioned, as to its nature, cause, and treatment. The literature of the disease is very meagre, and the views of those who have written concerning the affection are so at variance, that it is impossible to avoid the conclusion that they have seen and described different disorders, which have no other relation to each other than that they are all characterized by the one symptom of itching.

The names by which these different forms of pruritus have been designated, are almost as numerous as the localities in which they have been observed. Among others may be mentioned, prairie digs, Michigan itch, Texas mange, lumberman's itch, swamp itch, Ohio scratches, whore's itch, army itch, winter itch, etc.

A general description of the symptoms observed in the majority of these cases, as gathered from the articles on the subject published in various journals, chiefly of the West, is as follows: The affection begins usually rather suddenly, and is not preceded by any premonitory symptoms. The patient is, apparently without any cause, attacked by an intense pruritus, confined usually to the parts covered by the clothing. The itching is worse at night after the sufferer has retired, though he is not entirely free during the day. The sensations are described as itching, burning, or tingling. There is said to be, at times, a papular eruption, followed by the appearance of vesicles, pustules, and sometimes urticarial wheals. After a time the evidences of scratching become visible, and most writers, indeed, regard all the lesions as the direct result of this form of irritation, believing that the affection is a pure pruritus, unaccompanied by any primary lesions. Sometimes there are evidences of considerable dermatitis, the integument surrounding the lesions being of a bright scarlet hue, while a feeling of tension in the skin is complained of. The disease is said by some to be contagious, and many instances have been reported in which it seems difficult to exclude or explain away this element. On the other hand, others assert with equal confidence that no evidences of contagion are present, but that the pruritus occurs frequently in members of one family or community, simply because all are exposed to the same climatic conditions. It is said by some to occur only in those regions where the inhabitants are exposed to sudden and extensive variations of temperature. Others assert that it is as troublesome in milder climates and during the warmer seasons of the year, as it is in winter and in places where the temperature of the atmosphere is subject to great changes.

The affection is, by some, regarded as an eczema papulosum; others believe that the great majority of the cases are nothing more than pruritus hiemalis; some, again, look upon it as scabies pure and simple, while still others incline to the opinion that it is a disease *sui generis*, and due to the presence of a micro-organism in the layers of the skin. It is very probable that all of these different observers are right, and that there are several diseases grouped under the one name of prairie itch. Dr. J. N. Hyde, of Chicago, who has made a very careful study of pruritus hiemalis, believes that most cases of prairie itch are instances of the first-named disease, though he thinks that some cases of scabies, and possibly of other forms of disease, are included by various observers under this common designation. Dr. J. E. Engsted, of Dakota, has described a parasite which he has found in cases of prairie itch. The organisms appear as flattened cells, of varying lengths, arranged usually in chains of from five to twenty links, or as oval cells with from four to twenty hooklets projecting from their sides.

The treatment which has been recommended for prairie itch naturally varies according to the views that different observers hold concerning the nature and cause of the disease. Those who believe that the affection is contagious and due to the presence of a parasite, whether animal or vegetable, advise the employment of one or other of the various parasiticides, such as mercurial or sulphur ointments, naphthol, carbolic acid, hyposulphite of soda, etc. The secret of success, they say, is in the persistent and thorough application of these remedies; internal medication is without avail. Others, who reject the parasitic theory, also advise external applications, but of antipruritic rather than of antiparasitic remedies. Alkaline lotions, bismuth or starch powders, various preparations of carbolic acid, one part each of chloral and camphor in eight parts of unguentum aquæ rosæ, lead lotions, diachylon ointment, etc., are among the remedies of this sort which have been found more or less efficacious in different cases. Hyde insists upon regulation of the diet, and the avoidance of all articles of food or medicaments which are capable of exciting cutaneous rashes or of aggravating pruritic symptoms. Of course, strict cleanliness and the avoidance of underclothing made of rough and irritating material are very essential points in the treatment, whatever the cause or the nature of the pruritus may be.

During the fall of 1886, many short communications on prairie itch appeared in the medical journals of this country. The reader may find information of value in the issues at that time of the Detroit *Medical Age*, the *Journal of Cutaneous and Venereal Diseases*, the New York *Medical Record*, and other journals, chiefly those of the West.

Much assistance in the preparation of this brief sketch has been derived from the several articles in these journals, and also from a pamphlet on "The Affections of the Skin Induced by Temperature Variations in Cold Weather," by Dr. James Nevins Hyde, of Chicago.

T. L. S.

PREGNANCY. Pregnancy is the condition of a woman who has within her the product of conception. It begins with fecundation, and ends with the expulsion or removal of the fecundated ovule, no matter how far

the process of development has been carried, nor how long after development has ceased the ovum has been retained.

The word pregnancy, going back to its Latin etymology in the verb *gigno*, thence to the Greek *γενναω*, and finally to the Sanscrit *zan*, or *gan*, carries with it as the essential idea reproduction. But, on the other hand, the usual synonyms merely express one or another phenomenon of the pregnant condition. Thus, the English gestation, from the Latin *gestatio*, the German *Schwangerschaft*, and the Greek *κυεσις*, are each derived from a verb signifying in these different languages to carry; the Latin *graviditas*, and the Italian *gravidanza*, indicate the increased weight caused by pregnancy, and the French *grossesse* the greater size.

In normal pregnancy, the only variety which will be considered in this article, the fecundated ovule is developed in the cavity of the uterus—that is, the pregnancy is uterine, not extra-uterine. The pregnancy is simple, or single, when only one ovum occupies the uterus; but if two or more, it is called multiple, or pluriparous.

Duration of Pregnancy.—As has been indicated, a woman becomes pregnant when conception occurs, that is, if there is an actual union between the ovule and the spermatozoid, but when this occurs is one of nature's secrets which probably she will never reveal, and hence the actual beginning of pregnancy we cannot tell. Pregnancy, an internal incubation corresponding with the external which occurs in fowls, continues until the fœtus is best prepared to live external to the mother, and is usually regarded as lasting from about two hundred and seventy to two hundred and eighty days, or in other words, nine solar or ten lunar months. It is true that a fœtus born some weeks earlier than the shorter period stated may live, and therefore is said to be viable, though the chances of living lessen as the normal period of pregnancy is receded from. Obstetricians have, until recently, fixed upon seven months of intra-uterine life as the period when viability begins. But occasional exceptions have been observed, that is, children born at between six and seven months live; and as recently, by means of the *couveuse* and *gavage*, the number of exceptions is increasing, Tarnier suggests that this period should be six months, thus corresponding with the civil law of France, which makes a child legitimate if born at the expiration of one hundred and eighty days after the time when impregnation by the husband was possible.

Changes caused by Pregnancy.—Two important series of changes result from pregnancy—the one belonging to the impregnated ovule, and the other to the maternal organism. The former changes have been presented elsewhere in this work, and therefore there will be considered in this article only those concerning the mother.

The maternal alterations consequent upon pregnancy are conveniently divided into local and general. The former belong chiefly to the sexual organs, and will be first presented.

Changes in the Sexual Organs.—These organs in the female include those of reproduction, and those of lactation, and the alterations in each are to be considered in tracing the history of pregnancy. The most remarkable modifications occur in the organ of gestation, the uterus. It is the home for nine months of the new being, which in its rapid and marvellous development requires ample supply of nutritive material and constantly increasing room. But the uterus, in the earlier months or weeks of pregnancy, increases in size and capacity quite independently of any mechanical action of the ovum, for the latter is at first too small to produce such effects; and also, the changes just mentioned are observed when the uterus is quite empty, that is, when the pregnancy is extra-uterine.

The first modifications occur in the mucous membrane, which undergoes hypertrophy and hyperplasia, and furnishes the external covering of the ovum, the deciduous membrane. This deciduous membrane admits of a threefold division. First, that upon which the ovule rests, and which contributes to the formation of the placenta; this has been known from the time of John Hunter as the *decidua serotina*, because it was believed to be formed after the other deciduæ; second, that arising from the hypertrophied folds of this tissue between which the ovule is placed, and which uniting over it, make a complete covering, and which was called the *decidua reflexa*, because it was thought that the impregnated ovule entering the uterus, pushed away an exudate which was supposed to be formed as a consequence of impregnation, and which completely lined its cavity; and third, the decidua which occupies the rest of the internal surface of the uterus, but which in the latter part of the third, or early in the fourth, month of pregnancy unites with the decidua immediately covering the ovule, and is known as the *decidua vera*.

The peritoneal investment of the uterus undergoes remarkable increase, for without being thinned it still covers the organ enormously increased in size at the end of pregnancy.

The muscular tissue of the organ is greatly developed. Not only is there hypertrophy of already existing muscular fibres—these fibres becoming ten times longer and five times broader—but there is an actual hyperplasia, new contractile tissue being formed. Blood-vessels and nerves also increase in size; the veins indeed, in certain parts of the uterine wall, become so enlarged that they are called sinuses; hypertrophy of the lymphatics is well marked. The increased size of the uterus may, toward the end of pregnancy, result in part from passive stretching of the tissues composing its walls; but early in the pregnant state these walls are thicker than in the unimpregnated condition, and while the neck becomes greatly stretched and thinned, the fundus at the end of pregnancy remains thick; indeed, the entire wall of the body of the uterus may undergo even then no thinning in some cases. The weight of the uterus at the end of pregnancy is thirty-three times that of the nulliparous organ, eighteen times that of the parous. At this time its length is twelve inches and three-fourths, its breadth nine inches and a half, and its antero-posterior measurement nine inches. According to the late Sir James Simpson, the surface of the unimpregnated uterus is five or six square inches, and its capacity one cubic inch; but at the end of the pregnancy the former is three hundred and fifty square inches, and the latter four hundred cubic inches.

Changes in the form and the position of the uterus result from pregnancy. In the virgin the organ is at first pear-shaped, but flattened antero-posteriorly; the body of the uterus next becomes somewhat spheroidal in form, and finally the ovoidal shape is well marked, especially as the cavity of the neck contributes to the general uterine cavity, or in other words, effacement of the neck takes place; the larger end of the ovoid is above. At first the impregnated uterus sinks somewhat in the true pelvis, though this generally received statement is disputed by Tarnier; in the course of the fourth month, however, the increase in size of the organ is so great that there is not sufficient room in the pelvic cavity, and hence the uterus ascends; the process of ascension continues until, at the middle of the ninth month, the fundus reaches as high as the lower portion of the ensiform cartilage; and then, more especially if the subject be a primigravida, descent occurs, the presenting part of the fœtus, still, of course, enclosed in the uterus, enters the pelvic cavity, and the upper part of the womb, while lower than it was, projects more in front, causing a notable change in the form of the abdomen. In a multigravida the ascension is never so great, because the relaxed abdominal walls do not compel so decided a change, nor does the descent toward the end of pregnancy occur so soon—indeed it may not be manifested until labor actually begins. Of course, in case of a mal-presentation, this phenomenon fails. The gravid uterus is seldom found in the median line, but is usually inclined toward one or the other, in the great majority of cases the right, side. So, too, in the development of the uterus there is a torsion of the organ, a movement upon its longitudinal axis

by which the left side is thrown more anteriorly, while, of course, the right recedes; this fact is of importance when auscultating for the purpose of hearing the uterine souffle, for this sound, being most distinct at the sides of the uterus, will be best heard at that side to which the stethoscope can be most readily applied. Uterine torsion is readily explained by reference to the embryological development of the organ. Lateroversion of the uterus, the inclination being usually, as has been stated, toward the right side, should be remembered in performing the Cæsarean section, for after opening the abdominal cavity it is important, in order that incision of the uterus shall be made in the median line, to press the organ from the side to which it is inclined so that it will occupy a central position.

Changes in the properties of the uterus are to be considered. While the walls of the unimpregnated uterus are firm and resisting, with the progress of pregnancy they become yielding and elastic, thus permitting momentary changes in form resulting from fœtal movements, or from changes of position or other movements of the woman herself, or from external pressure. Following these various modifications in shape, as for example, those caused by fœtal movements, the uterus recovers its normal form, partly as a consequence of its elasticity, and in part from its retractility.

The sensibility of the uterus is only apparently, not really, increased; the size of the organ being so much greater, the latter is more exposed, and then, too, it is liable to certain pathological conditions which are characterized by more or less suffering referred to it. The irritability of the uterus is greater in pregnancy; the organ responds more readily to causes which excite the action of its muscular fibres, and in some subjects this reflex excitability is so decided that miscarriage is liable to result from comparatively trivial causes. But, on the other hand, this irritability in others is so slight that the greatest violences may be inflicted upon the subject without the pregnancy being interrupted. In consequence of the vast increase in the muscular tissue of the uterus, its contractile power is greatly augmented. This power is manifested first by what are known as the painless contractions of pregnancy, these contractions beginning as early as the fifth month, occurring at irregular intervals, and observed throughout the succeeding portion of pregnancy, and finally and chiefly by the contractions of labor, these contractions causing more or less suffering. The painless contractions of pregnancy are of importance in promoting the uterine venous circulation; they possibly contribute in slight degree in maintaining the attitude of the fœtus, as they are a factor in causing its position.

In addition to the changes already described, and which relate chiefly or exclusively to the body of the uterus, those occurring in the neck are to be mentioned. The neck of the womb undergoes only slight hypertrophy in pregnancy; it is less abundantly supplied with blood than the body is, and is not subjected to a stimulus from the growing ovum. The position of the neck depends upon the position of the body; thus, if the latter be inclined to the right side and anteriorly, the former will point to the left and backward. It should be remembered, however, especially if the subject be a multigravida, and the abdominal wall be greatly relaxed, there is in most cases more or less uterine anteflexion; this comparatively frequent condition should be borne in mind in those instances in which a bougie is introduced into the uterus for the purpose of bringing on premature labor, or the same object sought by introducing dilators into the cervical canal; for harm may result, or simply difficulty, from the effort to force any of these bodies in that which is the usual direction of the canal in the non-pregnant. Apparent shortening of the neck results from the ascension of the body of the uterus in the abdominal cavity, but actual shortening, it is generally held, does not occur in the majority of cases until the latter part of pregnancy—in many instances, indeed, not until just before the beginning of labor.

Early in pregnancy a change in consistence of that part of the intravaginal cervix immediately adjacent to the external os occurs, the superficial tissues becoming softer. This softening advances regularly and slowly in the primigravida, until it involves the entire vaginal portion, so that, approximately, one-fourth is affected at four months, one-half at six, three-fourths at seven, and the remaining fourth is also softened at eight months. In the multigravida the process is more rapid, because the vaginal portion is shorter, and because it has once or oftener previously undergone the change.

The form of the neck of the womb in the primigravida is at first more distinctly conical, but it soon becomes spindle-shaped from the accumulation of glandular secretions in the cervical canal; in the multigravida it is cylindrical, or somewhat expanded at its lower portion, so that it becomes club-shaped. The external orifice of the uterus in the former remains closed until the end of pregnancy; in only very rare instances it may be more or less permeable by the finger in the latter weeks of pregnancy. In multigravidæ the external os is not surrounded by a uniformly smooth surface, but the border is irregular and fissured, the most distinct of the fissures being found in the majority of cases upon the left side; the cervical canal is permeable by the finger to a distance directly related to the duration of the pregnancy, the finger readily passing to the middle of it at seven months; the cavity which the canal presents is funnel-shaped, or we may regard the neck of the womb as a hollow cone with its base below. The vagina is elongated by the ascension of the uterus; it is swollen, moister, its papillæ more distinct, and acquires a peculiar violet or purplish hue, arising from the increase of venous blood—this being one of the signs of pregnancy first pointed out by Jacquemin, and the value of which has recently been urged by Chadwick; greater arterial supply gives origin to the vaginal pulse, a sign of pregnancy which was pointed out by Osiander. The external genital organs are swollen, and have an increased secretion; the inner surfaces of the vulva may show a similar, though less marked, change of color to that observed in the walls of the vagina; varicose veins are found in some cases.

The ovaries, in consequence of changes in the broad ligaments, ascend in the abdominal cavity, come nearer the uterus, and have an almost vertical direction; they increase, according to Jacquemier, to about twice their usual size; ovulation, as a rule, is suspended, but the last *corpus luteum* undergoes remarkable hypertrophy, and disappears much later than that which follows menstruation without impregnation; indeed, it has been found well marked in women dying during the lying-in period. The broad ligaments open up their peritoneal folds to receive between them the enlarged uterus, and become almost vertical; they increase in length and thickness. The round ligaments become greatly hypertrophied, so that they can be readily felt in thin subjects then, and also during labor. In consequence of the greater increase of the posterior than of the anterior wall of the uterus, their uterine insertion, instead of being median as to the sides of the uterus, is now at the junction of the posterior four-fifths with the anterior fifth of the lateral face of the uterus; their hypertrophy and change of position prepare them for their office during labor, drawing the superior part of the uterus forward and downward, thus causing the uterine axis to be brought in correspondence, during a "pain," with the axis of the pelvic inlet. The development of the round ligaments in pregnancy, one of them being usually larger than the other, may furnish a probable prognosis as to the vigor of uterine contractions, for the greater that development, the greater likewise is that of the uterine muscular tissue.

The oviducts participate in the general hypertrophy, and, like the ovaries, occupy a vertical position.

The changes in the mammary glands are very important and characteristic. In some instances the breasts become larger at the beginning of pregnancy, but in the majority of cases no increase in size occurs until at the time of the first menstrual suppression; according to Zweifel, this enlargement probably depends upon accumulation of fat between the lobules. The breasts may

be the seat of occasional shooting pains, and there may be increased sensibility of the axillary glands. The superficial veins are larger and more distinct, their blue color strikingly contrasting with the whiteness of the skin; if the breasts are greatly enlarged, it is not unusual to observe striæ upon them similar to those found upon the abdominal wall. The latter part of the second, or in the third, month the nipple is found more prominent and sensitive, firmer and harder; then, too, possibly a milk-like fluid may spontaneously escape or be pressed from it, though this phenomenon does not usually occur until in the last three months, and, on the other hand, in some instances, has been observed independently of pregnancy. The changes in the areola surrounding the nipple are very characteristic. First an apparently emphysematous swelling is observed, then an alteration in color corresponding to that of the hair and of the skin, and hence in blondes simply a deep rose color, and in brunettes a brown which grows darker with the progress of pregnancy: change in color is least in those having red

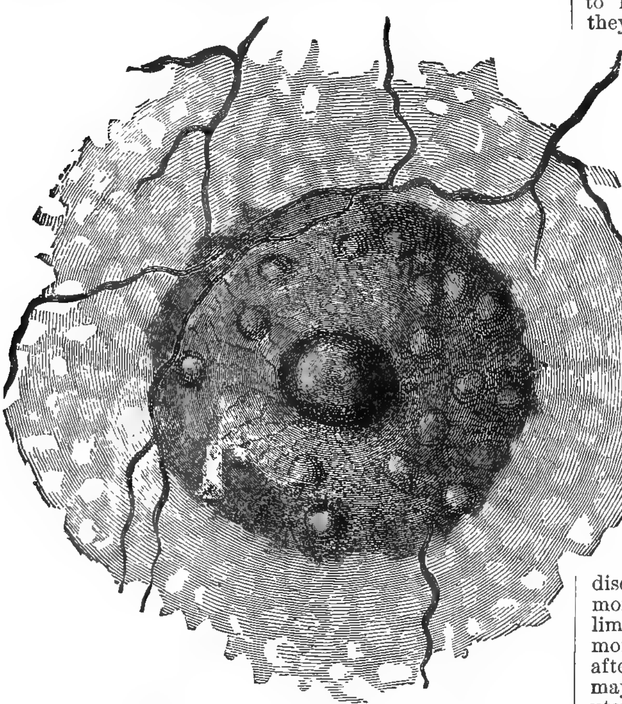

FIG. 3083.—Changes in the Breast caused by Pregnancy.

hair, and in them may even be not apparent. Montgomery's glands, the *glandulæ lactiferæ aberrantes* of Henle, notably increase in size, projecting from the sixteenth to the eighteenth of an inch. In addition to the primary areola, which has a radius of about one inch, a secondary areola surrounding it appears in the fifth or in the sixth month; this is lighter in color and flecked with whitish spots, presenting an appearance similar to a piece of dusty-white blotting-paper upon which drops of water have fallen. The illustration given above shows very well the changes that have been described in the nipple, the development of the glands of Montgomery, the appearance of the primary areola, and the formation of the secondary areola.

Disorders of urination are commonly observed during pregnancy. In the early weeks, in consequence of the pressure and sinking of the uterus, there usually is vesical irritability, while in the last weeks the descent of the presenting part of the fœtus into the pelvic cavity may, by pressure upon the urethra, cause ischuria. Pressure upon the rectum may produce constipation, though this is in many cases quite as frequently the result of the more sedentary habits of the woman when pregnant; partly as the consequence of the hyperæmia of the pelvic viscera generally, and partly from interruption by the enlarged uterus to venous return, hæmorrhoids are not uncommon in the pregnant woman.

The chief changes in the abdominal wall, in addition to its great stretching, are pigmentation over the *linea alba*, so that there is found a *linea nigra*, the formation of striæ, and the alterations in form of the umbilicus. The pigmentation referred to extends from the pubes to the navel, and, in some cases, above the latter, the discoloration then either forming a semicircle upon one side, or completely encircling it, before passing up toward the ensiform cartilage; the distinctness and the depth of the color are in relation to the color of the subject, and hence much more pronounced in the brunette. Abdominal striæ, the so-called cicatrices of pregnancy, occupy each side of the abdominal wall below the umbilicus, and are arranged in a series; they are in almost all cases present in first pregnancies, and it is not uncommon to find new ones in the multigravidæ. When recent they are a deep rose color, sometimes they are purplish, but after labor they become white or pearl-colored; generally the surface is depressed, but in some cases, as the result of serous effusion from compression of the epigastric vein, it is prominent. These striæ are the consequences of partial or complete atrophy of the lymph-spaces, partial atrophy of the skin, and longitudinal arrangement of the fibres of connective tissue. They may be absent in women who have borne many children, and they may be present in women who have never been pregnant; such instances, however, are exceptional.

During the first three months of pregnancy the umbilical depression is slightly increased, or remains unchanged; in the fifth month it is found notably lessened, and at seven months has disappeared; in the last two months there is more or less protrusion.

General Changes caused by Pregnancy.—Among the most important and earliest of the changes in the organism are those affecting the digestive organs. Gastric disturbance occurs in the first months of pregnancy in almost all cases. In some it may be so slight as scarcely to be an indisposition, only a transient discomfort; but in others so severe as to be a grave disease. From the fact that the nausea and vomiting are more frequent in the early part of the day—in some cases limited to this time—the condition is commonly called morning-sickness. Generally this disorder disappears after the first four months, but later in pregnancy there may be gastric irritability, caused by pressure of the uterus upon the stomach.

Both quantitative and qualitative changes in the blood occur in pregnancy. That there is an actual increase in the quantity of blood is proved by the larger area of the circulation and by the fulness of the vessels, a fulness which may contribute to the development of varicose veins, or to serous effusion. There is an increase in the watery portion of the blood and of the white cells, but a decrease in the albumen, the red corpuscles, and iron; the fibrin, normally 3 parts to 1,000, lessens until the sixth month, when it begins to become greater, and at the end of pregnancy is 4.3. Increased work is thrown upon the heart to send a larger quantity of blood through a larger area, and a consequent hypertrophy, involving especially the left ventricle, occurs.* The ascent of the

* Larcher, in 1857, first made known the fact of cardiac hypertrophy in pregnancy. He stated that this hypertrophy occurred chiefly in the left ventricle, its walls becoming one-fourth thicker at least, one-third at most. Ducrest confirmed the investigations of Larcher, and Blot further proved that the heart increased more than one-fifth in weight. Löhlein, among others, on the other hand, maintained that the cardiac hypertrophy of pregnancy does not exist. Zweifel states that the thorough investigations of Müller, of Jena, led him to conclude that this hypertrophy does occur, though not to the extent asserted by Larcher and others; and that the cardiac increase corresponds to the general increase of the body, for in every such increase the heart's muscular mass has a proportional increment.

diaphragm lessens the pulmonary capacity, so too the antero-posterior measurement of the chest decreases ; but there is a compensating increase in the transverse measurement; nevertheless, it seems doubtful if there be complete compensation, for the pregnant woman, when the uterus interferes most with the descent of the diaphragm, is liable to suffer from hurried breathing, as in rapid walking or in ascending steps. Resulting from the greater quantity of the blood and the greater arterial tension, the quantity of urine secreted increases ; this increase is almost exclusively of its watery portion ; all the solid constituents, with the exception of the chlorides, progressively lessen with the advance of the pregnancy. Nauche, in 1831, described what was at first thought to be an organic substance found upon the urine of pregnant women about thirty-six hours after it was passed, and which received the name of kyesteine, since it was regarded as characteristic of the pregnant condition ; this is a soft, grumous, white pellicle, which about the fifth day breaks up and falls to the bottom of the vessel. So far from being an organic substance, it is chiefly composed of ammonio-magnesian phosphates, vibrions, and monads ; it may be found upon the urine of the non-pregnant, as well as upon that of the male. It is not uncommon for the urine to be albuminous, especially in the latter part of pregnancy ; but if this be slight, and caused by vesical catarrh, the condition need give no anxiety. Still more rarely, sugar is found in the urine toward the end of pregnancy, and is simply significant of the elimination of milk-sugar ; true diabetes mellitus is rarely seen in pregnant women. According to the observations of Rokitansky, 1838, in more than one-half of pregnant women there are bone-like deposits upon the internal table of the cranial bones, and external to the dura mater, which he called osseous neoplasms or osteophytes. Similar deposits have also been found upon the internal surface of the pelvic bones of women dying in childbed. While these deposits are not exclusively found in connection with pregnancy, for they have also been observed in the tuberculous, yet they are more frequent in the former than in any other condition.

The spleen and also the thyroid gland increase in size ; it is probable, too, that the kidneys become somewhat larger in pregnancy.

Pregnancy causes greater nervous sensibility, and hence various reflex nervous disturbances may occur. Neuralgic affections, especially involving one or more teeth, are not uncommon ; often the severe toothache may require, or be thought to require, extraction of the painful organ, and women who have borne many children will sometimes say that every child has cost them a tooth. Many women are despondent and a prey to gloomy thoughts or grave apprehensions of danger, and in some actual insanity occurs ; but in the majority of instances of mental derangement hereditary influence is the important factor, pregnancy being merely the exciting cause.

A woman's weight increases about one-thirteenth during pregnancy, this increase being greatest in the last three months—being from one kilogram and a half to two kilograms (from 4 to 5½ pounds) each month.

Multiple Pregnancy.—When two or more fecundated ovules occupy the uterus, the pregnancy is called multiple, or pluriparous.

Twin pregnancy occurs once in 90 ; triple, once in 7,900 ; and quadruple, once in 370,000—though Neefe, quoted by Zweifel, makes the latter proportion 1 to 560,000 ; quintuple pregnancy is of course exceedingly rare. The frequency of pluriparous births varies in different countries, and, contrary to the opinion of Pliny, such births are not more frequent in warm climates ; thus they occur oftener in Denmark and Sweden than in France and Belgium.

The sex of the children is the same in sixty-four per cent., different in thirty-six per cent.

Multiparity and heredity seem to be the most important factors in the production of multiple pregnancy ; but in addition to these, other causes apparently are great stature, race, and the size of the ovaries.

In pluriparous inferior animals fecundation of ovules is simultaneous, and probably this is the fact in multiple pregnancy in the human female in the majority of cases ; nevertheless there are a few instances recorded where the fecundation was successive, so that it may be admitted that a woman who has already conceived may, while that product of conception remains, conceive again—in other words super-impregnation may occur. But super-impregnation includes super-fecundation, and super-fœtation. By the former is meant the fructification of ovules liberated about the same time, and by the latter the fructification of ovules escaping at an interval of weeks or even of months, an hypothesis that is generally rejected ; this rejection rests upon physiological and anatomical grounds. First, we have reason to believe that ovulation is suspended during pregnancy. Just as the hen does not lay eggs after she has begun setting, so the human female does not, while the process of internal incubation is going on, furnish any new ovules for impregnation. Then, too, between the third and fourth months the decidua covering the ovum and that lining the uterus are fused into a single membrane, so that ascension of the spermatozoids to the usual seat of impregnation is impossible, and also, entrance of the ovule, impregnated or not, into the uterus is for a like reason impossible. Therefore, while that variety of super-impregnation known as super-fecundation is admitted, the other, super-fœtation, is in the highest degree improbable, and after the fusion of the deciduous membranes, impossible. There is not space in the present article to consider and to answer the facts adduced in favor of the latter hypothesis.

In order that twin conception may occur, there may be, first, two ovules furnished by two ovisacs, both of the latter belonging to one ovary, or one from each ovary ; then there will be two corpora lutea. Second, one ovisac may contain two ovules ; this is not a mere hypothesis, for some observers have found an ovisac with even three ovules. Third, there may be two germinal vesicles in a single ovule, or the blastodermic membrane may divide into two. If the twins come from a single ovule, they are of the same sex.

In the first variety the twins are enclosed in separate sacs, the walls of which are made each of an amnion and of a chorion ; originally each sac had its separate decidual investment, but pressure caused absorption of the intervening decidual walls, so that then a single decidua covers them. The placentæ are completely separate, or united only by a membranous band, but in either case there is no vascular anastomosis. Yet it may also happen that, though the twin conception results from two ovules coming from different ovisacs, there is a common chorion, but separate amnions, and the explanation proposed is that originally each had its own chorion, but, as stated in regard to the two deciduæ becoming one, the intervening double chorion wall has undergone absorption. In these cases the placentæ make a single mass, but ordinarily the vessels do not anastomose. If the twins originate from a single ovule they are enclosed in a common sac, but of course originally each twin had its own amnion ; for that is a production from the embryo, and the fact of there being a common sac has the same explanation as that which has been given for the presence of a common decidua and a common chorion. The placentæ form a single mass, and the blood-vessels anastomose. According to Schatz (*Archiv für Gynäcol.*, Band xxxii.), usually there remains but one anastomosis, and that arterial ; sometimes there is also a venous anastomosis, and rarely two of each.

The weight and size of twins is usually under the average ; very frequently one is larger than the other ; in some cases a twin dies in the course of the pregnancy, while the other reaches complete development ; premature labor is frequently observed in twin pregnancies, still more is it the rule in other varieties of multiple pregnancy.

The diagnosis of pluriparous will be considered in connection with that of single pregnancy.

Diagnosis of Pregnancy.—This is a subject of very great importance with reference to the reputation of the

physician, and hence the honor of medicine, because the two are indissolubly united; but especially with reference to the reputation of the woman, supposing her to be falsely accused, and it may be with reference to her health, and in some cases her life even is at stake. The physician is liable to be deceived by false statements made by the woman herself; in some cases she herself is deceived, but in others she means to mislead, either for the purpose of concealing a true pregnancy, or else with the design of extorting money from the alleged father of her unborn offspring, or to secure an interest in an estate.

In the study of the signs of pregnancy, attention is first given to those of which the woman may inform us, then to those which we obtain by actual examination, the latter being such as we learn by the eye, by the ear, and by the sense of touch. The former are called subjective and the latter objective; probability only is given by subjective, but certainty by objective, signs.

The absence of menstruation, morning-sickness, increase in the size of the breasts, occasional pains in them, and their secretion taking place, the abdomen growing larger, and the sensation of quickening—that is, the mother's consciousness of the first fœtal movements—and the repetition from time to time of these movements, constitute the chief evidences of pregnancy which can be given by the woman herself. But there may be an amenorrhœa independently of pregnancy, or a girl may become pregnant before she has menstruated, or a woman during the temporary and normal absence of the periodic flow, as when she is nursing. On the other hand, there may be, especially in the early months of pregnancy, a bloody discharge from the uterus occurring periodically, which, though not menstruation, but a threatening of miscarriage, may be mistaken for the former. It should also be borne in mind that under the intense desire to be pregnant, or, on the other hand, the great fear of such condition, there may be what, from its etiology, has been appropriately termed psychical amenorrhœa. Nausea and vomiting, simulating the morning-sickness, may result from other causes, such as gastric disease, or reflex disorder. Enlargement of the abdomen may occur from neoplasms, or hypertrophies of normal tissues, or from ascitic disease. Some at least of the changes in the breasts that have been mentioned as occurring in pregnancy, may be the consequences of disease in the pelvis or abdomen, *e.g.*, they may occur in connection with the development of ovarian tumors. So far as the perception of fœtal movements by the subject herself is concerned, a woman may believe she recognizes them and be utterly mistaken, even though she has had the experience of such movements in several pregnancies. It is thus seen that none of these signs are positive proofs of pregnancy; the combination of two or more will make the event very probable, but even should they all be asserted to be present, the physician must not rest his diagnosis upon them, especially as certain signs are available.

In studying the objective signs of pregnancy we may conveniently divide them into those addressed to the sense of sight, of touch, and of hearing.

1. *Inspection.*—This includes observing the carriage, countenance, the breasts, the abdomen, and the vagina. The pregnant uterus, especially in multigravidæ in whom, from the relaxation of the abdominal walls, the enlarged organ falls forward, compels the woman to throw the shoulders farther back to compensate for the increased weight in front, and hence a change in the spinal curve. The face may show pigment deposit upon the forehead and the cheeks, constituting, when great, what has been called the mask of pregnancy. The face may be haggard and anxious, and the fulness of the features lessened, more especially in a pregnant woman who has suffered greatly from nausea and vomiting; but it has not the emaciation, the lines descending from the angles of the mouth, and other manifestations characteristic of the ovarian face. The breasts may be examined with reference to increased size, the presence of milk and of striæ, and the prominence of the nipple; and as to the changes in the areola, its swollen condition, development of Montgomery's glands, and darkened hue; if the fifth month of supposed pregnancy has passed, the secondary areola will be in process of formation. The abdomen may be observed as to increase in size, as to the changes in the umbilicus, the presence of the linea nigra, and of striæ, and in regard to the latter as to whether they are old or recent. The chief object in examining the vagina is to ascertain whether it shows the peculiar coloration to which Jacquemin, and more recently Chadwick, have attached such importance as an evidence of pregnancy. The latter, who has given much study to the subject, makes the following statement in the "Transactions of the American Gynecological Society," vol. xi.: "The color begins as a pale violet in the early months, becomes more bluish as pregnancy advances, until it often assumes finally a dusky, almost black, tint." He further states in reference to the cases examined by him, "that, while in the majority of cases the bluish tinge appeared over the whole vaginal entrance, there was a fair proportion in which the violet tint was confined to the anterior wall of the vagina, just below the urinary meatus, whence it shaded off into the normal pink color laterally. This, when distinctly perceptible, I soon found to be, in my practice, an absolutely sure sign of pregnancy. There were, furthermore, a very few in whom the blue tint was universal, but more accentuated on the posterior wall of the vaginal entrance, which I found was valueless as a sign of pregnancy unless the color was quite deep. The recognition of this peculiar localization of the blue tint on the anterior wall as a sure sign of pregnancy, I feel is the most important new point in this communication."

2. *Touch.*—Obstetric touch is usually applied to an examination made with one or more fingers, introduced into the vagina for the purpose of diagnosis. But the term should be given a far wider signification; we touch, whether the entire hand or only a single finger be employed, and so it is an appeal to the same sense, whether the application be made to the abdominal wall or through one of the canals opening from the lower part of the body—chiefly the vagina, more rarely the rectum, and still more rarely the urethra. To the application of the hand or hands to the abdomen the term external examination, or abdominal palpation, is given; internal and external examination may be made at the same time, the one assisting the other, and then the method is sometimes called the combined examination. By abdominal palpation we may recognize the uterus enlarged by pregnancy from its form, from its being the seat of intermittent contractions, from its containing within it a mobile body, the mobility being either spontaneous or communicated; we may distinguish different parts of that body—the feet, the back, the head, and the pelvis. Palpation is usually done with the woman lying upon her back, the head and shoulders slightly elevated, and the lower limbs moderately flexed, so that the abdominal wall is somewhat relaxed; it is important that the bladder and rectum shall have been recently emptied; the abdomen should be exposed as far down as the mons veneris. The examiner, his hands having been carefully washed and warmed, standing with his back toward the woman's face, and supposing him to be on the right side of the bed,* applies the left hand upon the hypogastrium, first gently, then presses with some firmness, this pressure being most marked at the ulnar side and made just as he is about to raise the hand to place it a little higher upon the abdomen. The ascending movement is made, similar pressure follows, and thus the manipulation is continued until the ulnar side suddenly meets with a marked lessening of resistance, so that it sinks, readily depressing the abdominal wall at that point, and the hand circumscribes the fundus.

Another method of beginning palpation, and by which the lateral boundaries of the uterus are first defined, is to

* By some it is advised to begin abdominal palpation by pressure with two hands upon various parts of the abdomen, so as to accustom it to such contact, and prevent contractions of its muscles; but this preliminary manipulation may be omitted in most cases, and direct exploration at once made.

place the palms of the hands in contact directly in the median line upon the lower part of the abdomen, as represented in the subjoined cut (Fig. 3085). Then the hands are gradually separated, the ulnar margin pressing downward upon the abdominal wall, until, having reached the sides of the uterus, they readily sink, and include be-

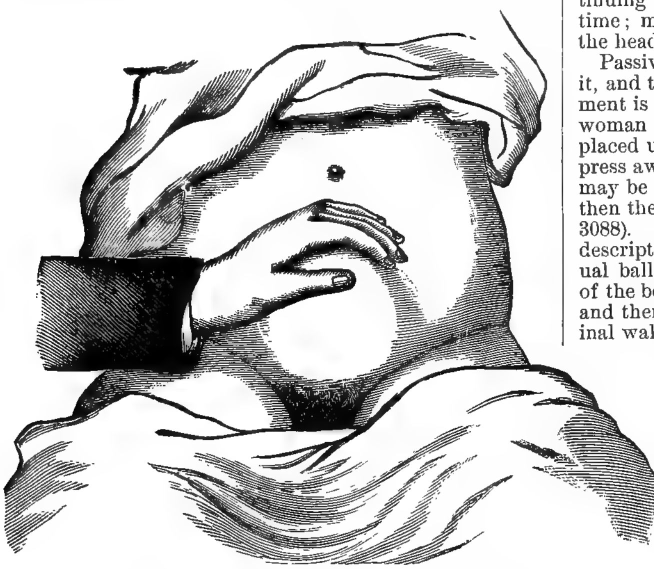

FIG. 3084.—Circumscribing the Fundus of the Uterus.

tween them this organ. It is not then difficult to have them pass farther and farther upward upon the side of the uterus, until the fundus is reached and can be circumscribed.

Dr. Braxton Hicks claims that if the uterus be examined without friction, or any pressure beyond that necessary for full contact of the hand, continuously over a period of from five to twenty minutes, it will be noticed to become firm if relaxed at first, and more or less flaccid

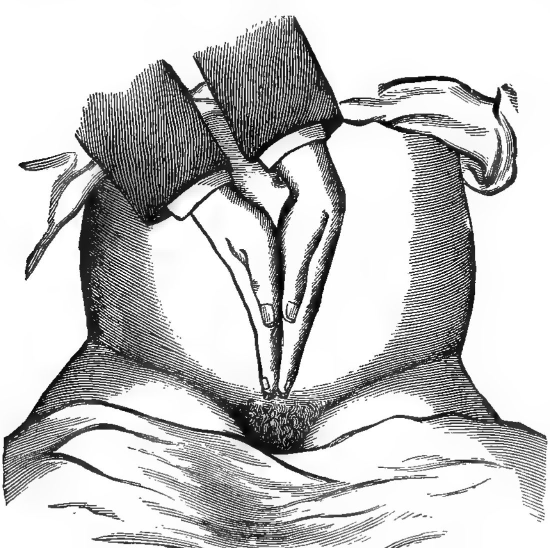

FIG. 3085.—Application of the Hands in the Median Line.

if it be firm at first; each contraction lasts from two to five minutes, and they are seldom separated by so long an interval as thirty minutes: he has found this sign as early as the last of the third month.

At five months the walls of the uterus have become so elastic and depressible, and the fœtus is so developed, that it can be recognized by palpation if the abdominal walls are not too thick. In this examination some parts of the uterine tumor readily yield, while others are resistant, and the latter may in some cases be recognized by continuing the manipulation on one part of the fœtus at a time; most probably in the lower part of the abdomen the head may be felt.

Passive movements may be given the fœtus, or part of it, and to such movements the term abdominal ballottement is given. Usually, in performing ballottement the woman lies upon her back, and the operator's hands are placed upon each side of the uterus; one hand is used to press away the fœtus toward the opposite side, or motion may be given to a part of the fœtus, as the head, and then the manœuvre is called cephalic ballottement (Fig. 3088). The late Dr. Albert H. Smith gave the following description of his method of performing external bimanual ballottement: The woman is placed upon the edge of the bed with her clothing removed from the abdomen, and then rolled upon her side so that the anterior abdominal wall projects over the edge of the bed; then the rotation of her body is carried still farther, until the enlarged uterus becomes so dependent that it may be supported by the hand placed beneath it, while the other hand makes counter-pressure upon the opposite side of the uterine mass. Thus let the woman be upon her left side, the right side, therefore, being above; the examiner takes his seat with his face toward her head, his left side being toward the pendent abdominal mass, but about opposite the hips. The right hand is then passed far under the uterus as it projects over the bed, the palmar surface being in contact with the abdominal integument and the ulnar edge toward the iliac bone. The left hand is then placed similarly upon the right side of the abdomen, making counter-pressure upon the opposite side of the uterine body so as to grasp it between the two palms. This gives a full command of the tumor, and enables the examiner to apprehend the shape and density of the mass, its fluctuating character, the movement of a separate body in it, which can be operated upon by manipulation and repercussion.

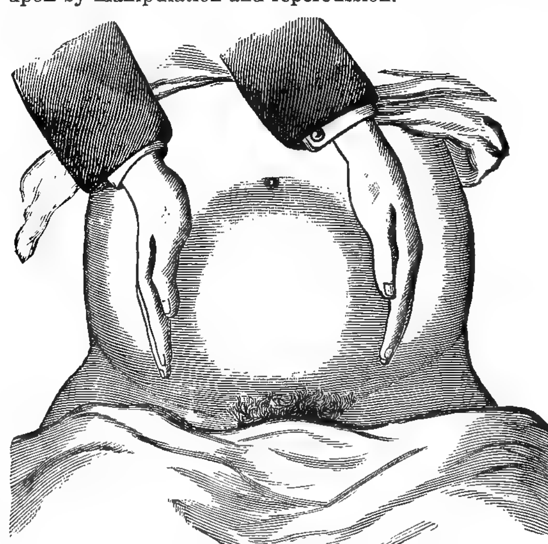

FIG. 3086.—Application of the Hands to the Sides of the Uterus.

Spontaneous movements of the fœtus, which can be readily recognized, are almost certain to occur during abdominal palpation, if the pregnancy has advanced to five months; these movements may be of the entire body or of a member, and in the latter case they are short,

quick taps, for the moment causing a projection at that part of the uterine wall against which the blow is given, and hence may be seen as well as felt; if the entire body

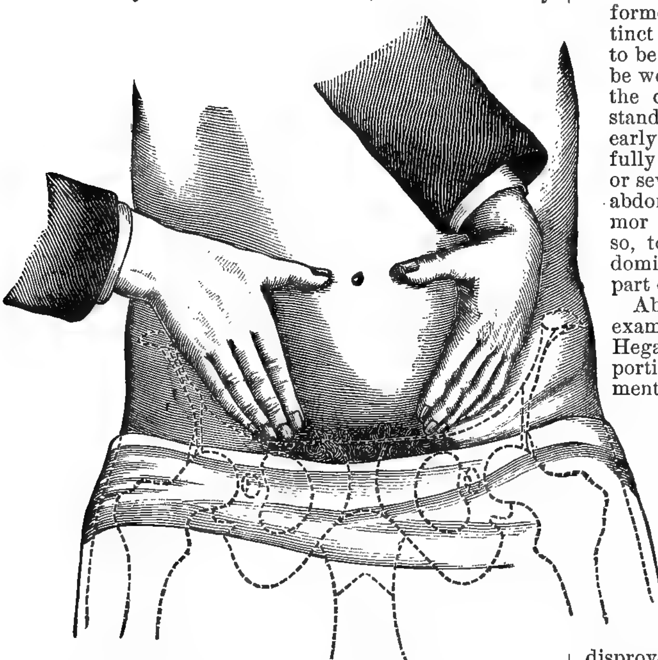

FIG. 3087—The Fœtal Head included between the Examiner's Hands.

moves the motion is slow and gliding, and there is no sudden localized change in the form of the uterus.

By palpation it is possible in most cases, when the pregnancy has advanced to seven months, to recognize different parts of the fœtus, as, for example, the head and the breech with the intermediate back, and also parts of the lower limbs.

By the vaginal examination we chiefly seek to learn the form, position, size, and consistence of the vaginal neck, and condition of the external os and cervical canal. It is in almost all cases made with the woman lying upon her back and the lower limbs moderately flexed. The index-finger of the right or of the left hand is generally employed; by using the medius also a gain of a little more than a third of an inch is secured, but the introduction of two fingers may in some cases be very painful, and a single finger has a greater facility of movement, and also more clearly defined sensation. Softening and some enlargement of the neck of the uterus will be ascertained in case the woman be pregnant, and supposing an antero-lateral inclination of the body of the uterus, the neck is found pointing in an opposite direction. The os in the primigravida is round, instead of being a transverse depression; but in almost all cases the tip of the finger cannot enter it, or if it does, is arrested soon after entrance. On the other hand, the os in the multigravida presents an irregular border, marked by fissures and intervening prominences, the fissures being most distinct upon the sides, and the cervical canal is open to a degree in direct relation with the period of pregnancy—the finger, for example, readily passing to the middle of the canal at seven months; the cavity thus entered is funnel-shaped.

Vaginal ballottement is performed with the subject lying, or standing. If in the former position, it is well to press upon the hypogastrium with the free hand, so as to force the lower portion nearer the index-finger of the other hand; or in this case the index and medius may be introduced into the vagina, placed either in front of the cervix or behind it, the latter position being usually preferred; the finger or fingers are made to press firmly against the uterus and upon the fœtal part resting on the latter, and quick pushing upward is made, the movement being thus communicated to the fœtal part, which is for the moment displaced, but afterward returns to its former position; the movement of return is less distinct than that of displacement, and possibly may fail to be recognized. If the woman's shoulders and head be well elevated, the finger may be placed in front of the cervix, the position also selected should she be standing. The latter part of the fifth month is as early as vaginal ballottement can, as a rule, be successfully made, but this sign becomes most distinct at six or seven months. By combining vaginal touch with abdominal palpation the continuity of a doubtful tumor felt in the abdomen with the cervix is proved; so, too, this pressure upon the uterus through the abdominal wall facilitates vaginal examination of the part of the organ accessible to the finger or fingers.

Abdominal pressure is also combined with digital examination through the rectum for the recognition of Hegar's sign, an early softening and relaxation of that portion of the uterus immediately above the attachment of the utero-sacral ligaments, or the posterior portion of the lower uterine segment.

3. *Obstetric Auscultation.*—This is a discovery of the present century. In 1818, Mayor, of Geneva, examining the abdomen of a pregnant woman, first heard the sounds of the fœtal heart, and three years later Kergaradec, of Lausanne, ignorant of the prior success of Mayor, made the same discovery. In addition to this sound Kergaradec also heard a bruit to which, having an erroneous hypothesis of its cause, he gave the name of placental souffle, a name which some writers still use, in spite of the error long ago disproved, instead of calling it the uterine souffle. In addition to these sounds, others may be heard, such as the funic souffle, and those caused by the movements of the fœtus; but the first two are the most important, and they only will be here considered.

The room in which auscultation is made should be

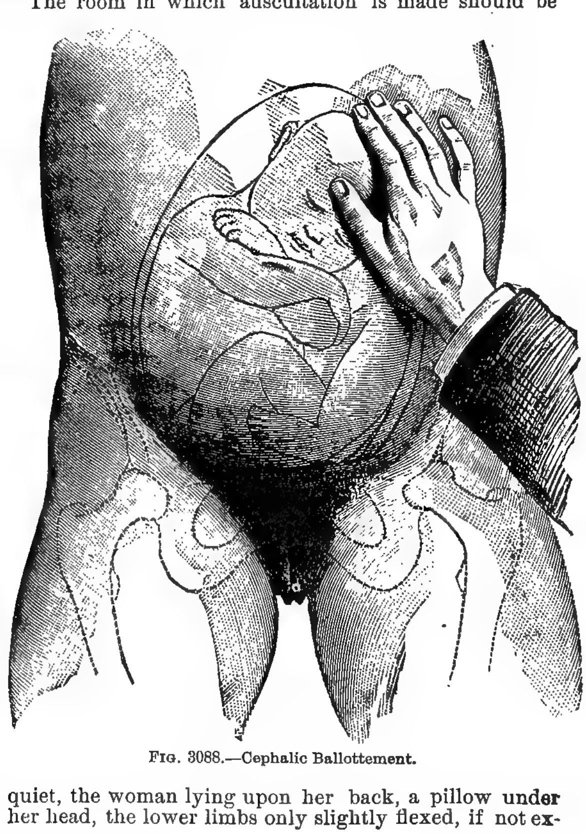

FIG. 3088.—Cephalic Ballottement.

quiet, the woman lying upon her back, a pillow under her head, the lower limbs only slightly flexed, if not ex-

tended, the abdomen naked—though a thin, unstarched muslin or linen covering will in most cases not interfere materially with the examination ; as a rule, a stethoscope should be employed, not only from motives of delicacy, but also for the more certain limitation of the part where certain sounds are heard, and because the ear cannot be readily applied to certain portions of the abdomen where it may be necessary to listen ; nevertheless, the pressure of a stethoscope may in some cases be painful, while the direct application of the ear is readily tolerated, or, again, some may be able to hear more readily without than with an instrument. This examination may be made as early as the last of the fourth month, but for the majority of practitioners, probably, the proofs thence derived of pregnancy will not be distinctly obtained until some time in the fifth month.

The part to which the stethoscope should be applied will be determined by the period of pregnancy, and by whether the sounds of the fœtal heart or the uterine souffle is sought. Should he seek the former, the pregnancy being only four or five months advanced, he will generally best succeed by placing the instrument, in or near the median line, upon the fundus of the uterus, and in a position approximating the axis of the pelvic inlet ; but if the examination be made in the last three months, the uterus having now its ovoidal form, and the long axis of the fœtus corresponding with that of the organ which it occupies, then he should listen at one of the four points, in order, D, C, A, and B (see Fig. 3089).

Obviously, the fœtal heart-sounds will be heard most distinctly through the back of the fœtus, for the dorsal plane of the fœtus by its convexity is better adapted to the concavity of the internal uterine wall, and besides, with the superior members folded over the anterior chest, the heart is consequently made more remote; and, finally, the lungs being not expanded, the heart-sounds are heard posteriorly better than after pulmonary respiration has begun.

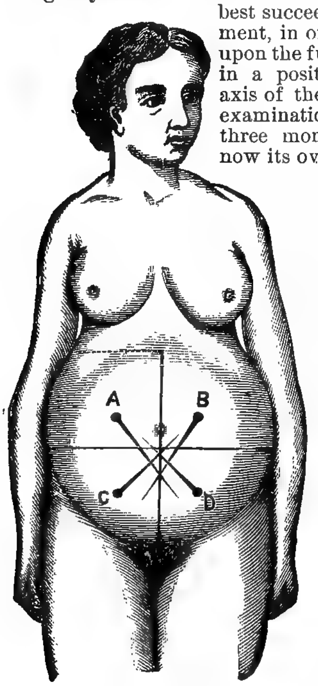

FIG. 3089.

As in the great majority of cases the head is in the lower part of the uterus, the fœtal heart-sounds will be heard most distinctly at some point below a transverse line upon the abdomen passing through the umbilicus. But still more, as in by far the greater number of instances the occiput of the fœtus is in the left side of the pelvis, usually directed toward the left ilio-pectineal eminence, these sounds are most frequently heard with the greatest distinctness upon the left lower of the four spaces into which the abdomen of the mother is supposed to be divided (see Fig. 3089), and usually at a point corresponding to the middle of a line drawn from the umbilicus to the left ilio-pectineal eminence. But if not heard satisfactorily at this place, or in its vicinity, corresponding positions upon the opposite side should be tried. All these failing, the two upper divisions should be examined, for the head, instead of being below, may be above—in other words, there is a pelvic presentation. So much of an explanation seemed necessary, though in consequence of it there is suggested a part of the diagnosis of presentation by this means, in regard to the parts of the abdominal wall to which the stethoscope should be applied in listening for the fœtal heart. The mean frequency of the pulsations of the fœtal heart is, according to some, 140, but according to others, 135; temporary variations, not only in the frequency, but also in the force, of these pulsations are common. The sound is double and rhythmic ; the first bruit is the clearer and more distinct ; a brief pause ensues, and the second is heard, which is followed by a longer interval before the double bruit is repeated.

The uterine souffle is usually heard best at the lower part of the uterus and at its sides, especially the left, which, for reasons previously given, is brought nearer the anterior abdominal wall. This sound is synchronous with the mother's pulse, but without shock ; it is somewhat similar to the sound heard when the stethoscope is applied to a varicose aneurism, but it varies with the pressure made by the instrument, with uterine contractions, and from one time to another, and with the different parts examined, and it is usually not harsh. It may be heard earlier than the sounds of the fœtal heart, in some cases at the beginning of the third month. But it is not a conclusive, only a probable, proof of pregnancy. This, as well as the fact that the placenta is foreign to its production, is proved by the following

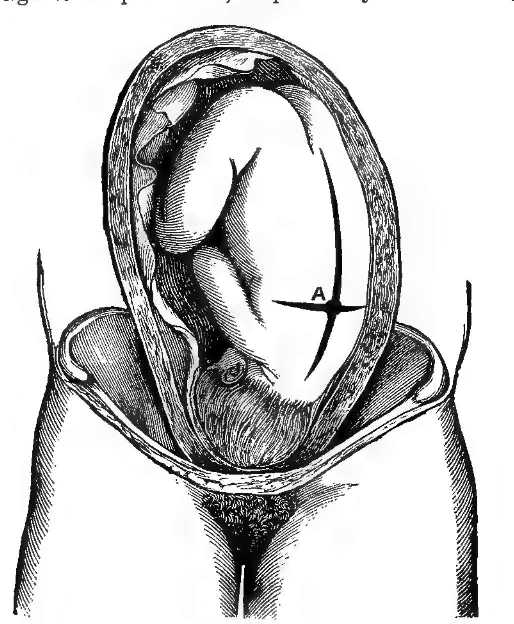

FIG. 3090.

facts : It may be heard in many cases in which the uterus is greatly increased in size from fibroid disease ; it is also heard, in nine cases out of ten, two to three days after labor.

The conclusive proofs of pregnancy are hearing the sounds of the fœtal heart, feeling—possibly, also, seeing —fœtal movements, and recognizing the fœtus by palpation.

Diagnosis of Multiple Pregnancy.—Practically, this discussion may be limited to the diagnosis of twins in the uterus, for the other varieties of pluriparous pregnancy are comparatively very rare. Among the probable signs are greater development of the uterus than in single pregnancy; this development is unsymmetrical, a vertical furrow dividing the organ apparently in two parts ; the abdomen appears to be especially distended at the sides ; fœtal movements are observed at different parts of the uterus, and, finally, the accidents of pregnancy are more frequently observed. The subjoined illustrations from Budin show how fallacious some of the proofs of twin pregnancy may be. In the first the positions usually occupied by the fœtuses are given ; both may present by the head, or both by the pelvis, or one by the head and the other by the pelvis ; but whatever the presentations, the fœtuses are usually side by side. But in

the second drawing one fœtus is in front, and in the third, one is above the other.

The only certain proofs of twin pregnancy are given by abdominal palpation and auscultation. Thus, by the

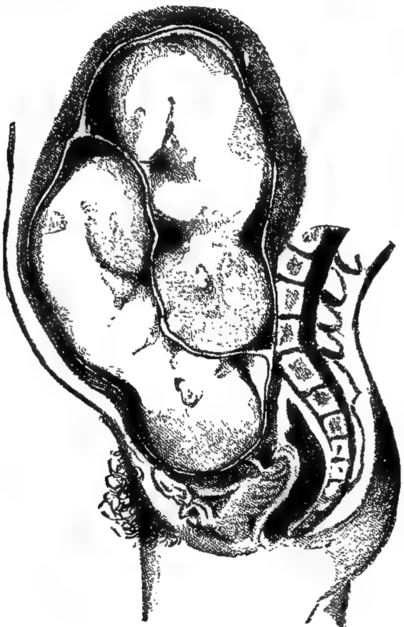

Fig. 3091.

former two heads may be felt in different parts of the uterus, and by the latter two fœtal hearts are heard, with maxima of intensity in different parts, also, of the organ. These sounds differ in frequency; the difference may be

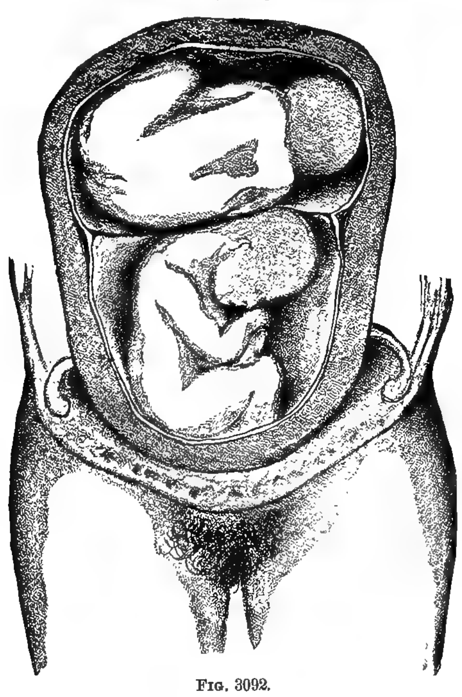

Fig. 3092.

only six or eight, or it may be ten or fifteen, but it is always present.

It should be remembered, however, that very great difficulty in making the diagnosis of twin pregnancy by auscultation will be presented in those cases in which the twins occupy the unusual positions as given in Figs. 3091 and 3092.

Differential Diagnosis of Pregnancy.—It is important to

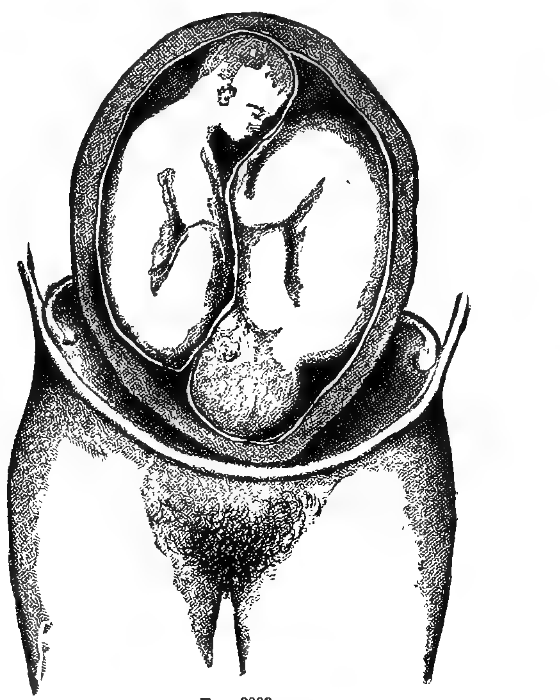

Fig. 3093.

refer to some pathological conditions which may be confounded with pregnancy, and briefly state the means by which error may be avoided. *Hæmatometra:* The enlargement of the uterus is slower, and occurs by sud-

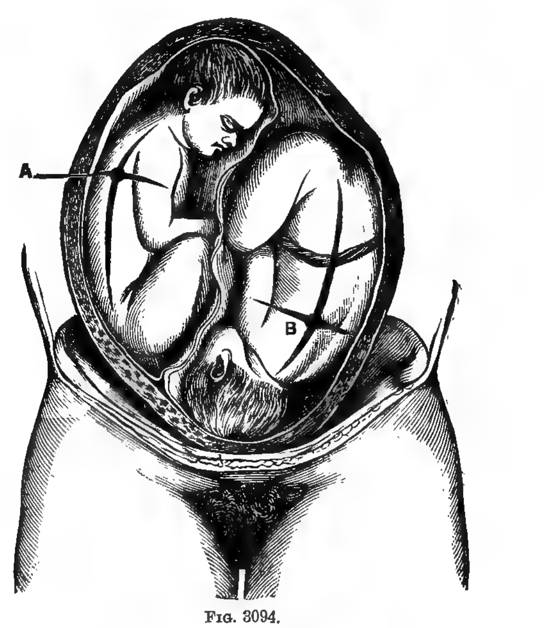

Fig. 3094.

den, not by gradual, increase, and this sudden increase is at more or less regular intervals. Neither vaginal nor abdominal ballottement is possible, and obstetric palpation and auscultation give negative results. *Uterine*

Fibroids: These are slower in development, and the uterus is hard instead of elastic, and generally irregular in form; menstruation, instead of being absent, is usually abnormal, there being menorrhagia, and there may be likewise metrorrhagia; by vaginal touch, absence of the changes in the cervix and os characteristic of pregnancy, often, too, some portion of the hard, irregular fibroid, may be felt; abdominal palpation and auscultation give negative results, except that by the latter the uterine souffle may in many cases be recognized. *Ovarian Tumor:* Usually slower in development, and if of considerable size, marked impairment of general health with considerable emaciation; the history of the growth, if it can be obtained, shows that the enlargement, instead of being at first median, was upon one or the other side; menstruation usually not absent unless the health has been greatly deteriorated; marked fluctuation in most cases when the tumor has attained considerable size; absence of proofs of pregnancy upon palpation and auscultation; and vaginal examination will in most cases be able to prove displacement, but no material enlargement of the uterus.

Uterus Enlarged by Chronic Parenchymatous Metritis.—Menstruation may be irregular, but there is not absolute amenorrhœa; the uterine wall, though somewhat softened, is not elastic and yielding as in pregnancy, and moreover it is sensitive, pain being caused upon pressure, which is not observed when pressing the gravid organ.

Accumulation of fat in the abdominal walls, ascites, tumors of the spleen, need only be mentioned in order that the practitioner may be put upon his guard against error from any of these sources.

It should be remembered that in all doubtful cases time is one of the most important elements of diagnosis; if a woman be pregnant, the fact will become clearer from day to day, for unequivocal signs of the condition will surely come. Therefore he is wisest who waits in such cases until he knows, either by the presence or the absence of these certain proofs, before he gives an opinion, and not he who risks a happy guess, or draws a conclusion from an average of probabilities.

THE HYGIENE OF PREGNANCY.—This includes attention to diet and the condition of the digestive organs, exercise, rest, clothing, sleep, the care of the breasts, and the condition of the mind. In the early months of pregnancy, it is not unusual for the irritability of the stomach to cause lessened desire for food, or possibly the appetite may crave some unusual article of diet; each condition must be considered and respected in the choice of aliments, and in directing the quantity. In some cases the morning-sickness is lessened by having the patient take her breakfast in bed, and not rise until an hour or two after. Generally, in the fourth month gastric disorder disappears, and the appetite is good; digestible and nutritious food, both animal and vegetable, may be taken, and, so far as possible, dietetic means used for the prevention of constipation. As in the ascension of the uterus in the latter months it comes to press upon the stomach, the meals should not be so abundant, but more frequent, and especial care should be taken not to eat heartily in the evening. If the constipation is not relieved by diet, an evacuation should be secured each day by a Seidlitz powder, Hunyadi, compound licorice powder, calcined magnesia, or some similar means.

Care must be taken that the clothing does not compress the abdomen or chest, and it ought to be suitable for the season; especially ought the pregnant woman to avoid being chilled, lest an annoying bronchitis, for example, or a serious nephritis with albuminuria, result from sudden suppression of perspiration. Moderate exercise will be useful, but that which fatigues or is violent, such as dancing, riding on horseback, or over rough roads, must be avoided. Long journeys by sea or land ought, if possible, to be postponed; the fatigue, the excitement, the constant jarring for several days consecutively on a railway train, for example, and the possible dangers and accidents belonging to travel in general, present strong arguments in favor of the advice just given. So, too, fresh air is especially necessary for the pregnant woman—she is breathing for two, and therefore must not be in crowded or badly ventilated rooms. The pregnant woman should observe regular hours of sleep, and it is also well for her to have a brief rest during a part of each day, lying down even if she does not sleep. A warm bath may be taken as usual, but hot baths, especially if frequent and prolonged, may cause abortion; sea-bathing, unless the water is quite warm, is not advisable, and when such baths are taken they must be without great exercise, as in swimming, and they ought to be brief.

The belief held by many philosophers as far back as Plato, and also by many eminent physicians as well as by the public, is becoming stronger, that the condition of the mother's mind has an important influence upon her unborn child; not only is it held that certain deformities may result from maternal impressions, but modifications of the intellectual and moral character, as manifested in after years, may have their origin in the mental state of the pregnant woman. Hence the importance of the prospective mother preserving an equable condition of mind, and as cheerful a disposition as possible; she should be carefully guarded against all injurious influences, and exposure to perils and to painful sights, and there ought to be thrown around her all protecting care and thoughtful kindness.

Sexual intercourse during pregnancy is utterly unnatural; it is a frequent cause of abortions; it is probably regarded with indifference or abhorrence by most women, and is without any moral justification. Many pagan nations have not only condemned this violation of natural law, but coupled severe punishment with the condemnation.

All compression of the mammary glands must be avoided; the nipples especially should be given ample room for their development, and if retracted they ought to be drawn out by means of the thumb and finger for a few minutes each day, and in the intervals a nipple-shield may be worn over them for a time. It is customary to endeavor to harden the skin, so as to prevent the formation of fissures and abrasions from nursing, by washing the nipple each day with alcohol holding in suspension or solution an active astringent. I have for some time protested against this practice, on the ground that the alcohol dissolves the sebaceous secretion with which nature has so abundantly supplied these organs, and which is their best protection from the injurious contact of fluids; even if the skin may be hardened by alcohol or an astringent, nature intended it to be soft and pliable, and not harsh and resistant, and consequently much more liable to be fissured. Therefore, let me advise, instead of the time-honored applications, scrupulous cleanliness of the nipples, the daily washing to be followed by bathing them gently with cologne or tincture of arnica and water, and at night the application of a little cocoa-butter. Delore suggests daily exposure of the nipple to the air as a means of rendering it less liable to become diseased during lactation. Certainly, if the exhibition of as much of the mammary glands as is made by some fashionable women at balls or parties has any justification, it would be in the fact that these women are pregnant, and are preparing for one of the most important duties of motherhood.

PROFESSIONAL CARE DURING PREGNANCY.—The obstetrician should see a woman from time to time during her pregnancy, giving her such instruction and advice as her condition may require. During the last three months, earlier if certain symptoms to be presented hereafter arise, it is important that the state of the renal functions should be learned, more especially as to the presence of albumen in the urine; once in one or at most in two weeks, the condition of the urine should be ascertained by chemical, and if necessary by microscopical, examination.

It would be better too, if at least an external examination were made when the fœtus has become viable, so as to ascertain the position which it occupies in the uterus, and the presence or absence of any neoplasms of the organ of gestation, or of organs adjacent, which may interfere with labor at the normal time. Some cases, too, may

require measurements of the pelvis to be made, especially in a primigravida, or in a woman whose previous labors have been difficult, requiring artificial means for the removal of the child, or in whom possibly the delivery was spontaneous, the child, however, dying in the labor, from the delay and difficulty of the process.

THE PATHOLOGY OF PREGNANCY.—The pathology of pregnancy includes, first, those diseases which are exaggerations of physiological conditions belonging to the pregnant condition, or caused by it; second, diseases beginning before pregnancy, or accidentally occurring during it, that is intercurrent, and which may be modified by the pregnant state or may affect it, and traumatisms, including injuries and surgical operations; third, affections of the sexual organs; and, fourth, maladies of the ovum. These classes will be now briefly considered in their order, omitting, however, from this presentation any of the diseases embraced in this class that are discussed elsewhere in this work.

Hyperemesis.—The morning-sickness of pregnancy, in its ordinary form, has been previously mentioned, and we are now concerned with that exaggeration of the disorder known as hyperemesis, or as the uncontrollable, incoercible, or pernicious vomiting of pregnancy. In about two-thirds of the cases this disease is first manifested before the end of the third month. Usually there is a gradual transition, from the ordinary nausea and vomiting to the grave form of the disorder, when the patient rejects the simplest food or drink, very soon after taking it, and then a part only of the food is vomited; in some cases, however, there is immediate vomiting—for example, simply a little cold water is thrown up immediately after it is swallowed, but more frequently it is retained until it becomes warm. Apparently the most trivial causes will excite vomiting, such as an attempt to sit up, or changing from one position to another, for example, from the back to the side, or when a reverse movement is made. The patient rapidly emaciates, the urine becomes scanty, may contain albumen, and is high-colored; there is in some cases an abundant secretion of saliva, and usually anorexia is present—in part probably from the patient's knowing that taking food will be followed by vomiting.

With the continuance of the disorder the symptoms become graver, and that which has been described as the second stage occurs. The emaciation makes rapid progress, and the patient becomes more exhausted, fainting, it may be, upon so slight exertion as sitting up in bed; the gums may be swollen, the teeth covered with sordes, and the breath offensive; the pulse is 120 or more a minute, and the thirst excessive. Older observers, without the proof of thermometric facts, described this stage as febrile, the conclusion being derived from the frequency of the pulse; but some recent observations do not prove a marked increase in the temperature. The third period soon follows. Now the vomiting ceases, but there are disordered vision and hearing, and often intense neuralgic pains; the pulse may be 140 a minute; mental disorder is shown in hallucination and delirium, and coma closes the scene.

The disease is not always steadily progressive, but presents, it may be, from time to time remissions, consequent, for example, upon a change of scene, or upon some new article of food or of drink. I have known one instance in which the vomiting ceased for some days from drinking lager-beer. Cazeaux quotes from Dubois an instance of grave vomiting in pregnancy, in which the disease disappeared after a violent attack of diarrhœa, and another in which a powerful mental impression, the husband of the patient gravely suffering from strangulated hernia, had a similar effect.

Among causes of obstinate vomiting in pregnancy are displacements of the uterus, inflammation of the cervix, adhesions of the membranes at the internal os, rigidity of the muscular fibres of the uterus not permitting ready dilatation, circumscribed inflammation of the organ, and inflammation of structures adjacent to it; Lebert and Rosenthal refer the disorder in some cases to partial manifestations of a general nerve inanition.

Post-mortem examinations have shown disease of different organs, more especially of the stomach—ulceration and cancer, for example—but, as Tarnier observes, it is impossible to describe the pathological anatomy of the disease, and while actual alterations in certain organs have been found, there is no constancy in these facts, and in some instances no lesion can be discovered.

Guéniot found that in 118 cases the recovery took place in 72, and 46 died; of the 72 who recovered, 42 either spontaneously aborted, or else premature labor or abortion was induced. Of the 46 who died, 28 did not abort, and 18 had abortion or premature labor induced, or miscarriage was spontaneous.

The treatment is hygienic, medical, or obstetrical. A change of residence, as from the city to the country, an entirely new diet, especially choosing an article of nourishment for which there may be a particular desire. Possibly iced lime-water and milk, or ice-cream may be tolerated and prepare the way for taking other food; effervescent drinks may be employed. Finally, absolute rest may be given the stomach for a time, rectal alimentation being employed. The medicines advised are very many, and by their number testify to the fact that results accomplished are quite uncertain. Among these are tincture of nux vomica, oxalate of cerium, dilute hydrocyanic acid, subnitrate of bismuth, chloroform, or sulphuric ether, each of the two latter given in doses of a few drops with water, or in perles, the various preparations of pepsine, chloral, bromide of potassium, and opium or one of its liquid forms, or morphia. Inhalations of oxygen have occasionally succeeded, and also the use of electricity; recently, too, cocaine has been strongly recommended. The application of ether spray to the epigastrium has been employed; so, too, have Chapman's ice-bags to the spine; a small blister to the epigastrium, in some cases followed by the use of morphia endermically, has relieved some.

Of course a uterine displacement should be corrected; cauterization of the cervix, and the application of belladonna to the vaginal portion has been employed with occasional success; Copeman used digital dilatation of the cervical canal, while others have leeched the cervix.

The obstetric treatment consists in the induction of abortion, or, if the pregnancy has continued until the child is viable, of premature labor. But this grave step is rarely required, and ought not to be undertaken until the usual means for the arrest of the disease have been vainly tried, and until the condition of the patient is such that her life is in imminent peril from the disease; it should also be borne in mind, that while in the majority of cases the vomiting ceases when the uterus is emptied, or soon after, there are some in which no such happy result follows; and, on the other hand, that cases now and then are seen in which the disorder is most grave and has persisted notwithstanding well-directed remedies, so that the practitioner despairs of a favorable ending, and yet, with some slight dietetic or medicinal change sudden improvement takes place and the disease ceases. The responsibility of ending the pregnancy ought to be shared with a reliable confrère.

Finally, the induction of abortion is not to be thought of if the patient has passed into the third stage of the disease, for then death is inevitable, and may be hastened by this treatment, bringing reproach alike upon the method and the art.

Serous Cachexia or Hydræmia.—Among the exaggerations of the physiological changes of pregnancy is that condition which Stoltz, and before him, according to Tarnier, Baudelocque, the nephew, and Lasserre, called a serous cachexia; Kiwisch gave the name of serous plethora to those blood changes consisting of increase of the quantity of blood and of its water. Stoltz speaks of the serous cachexia as an exaggerated hydræmia.

Patients suffering from this condition may have œdema of the lower limbs only, but frequently the serous effusion involves the connective tissue of the external generative organs, the upper limbs, the trunk, and the face; there may also be effusion of serum in the great serous cavities. If there should be disease of the heart the

symptoms are more serious. Nevertheless, notwithstanding this general or localized dropsy, the urine is entirely free from, or contains only a trace of, albumen.

The treatment should consist in rest, nutritious diet, the administration of tonics, especially of iron, the hot bath, diuretics, and occasional mild derivation to the intestinal canal. Tarnier attaches great importance to milk diet. In some cases punctures of the swollen external genitals or of the œdematous lower limbs may be advisable, but should not be made unless the necessity be urgent, lest gangrene ensue. If there is great accumulation of serum in either the thoracic or the abdominal cavity, thoracentesis or abdominal paracentesis may be employed without hesitation. Charles has recently recorded in the *Journal d'Accouchements* a fatal result in a woman near the close of her pregnancy, in whom the most prominent symptom was this hydræmia.

Anæmia.—Those who suffer from hydræmia are anæmic, but there may be an anæmia not marked by serous effusions, or, at least, there is only a moderate œdema, more especially of the lower limbs. Such a condition creates a liability to post-partum hæmorrhage, and should be corrected by attention to nutrition, and by the use of tonics, especially of iron preparations.

Pernicious Anæmia.—In addition to the simple form of anæmia just mentioned, there is a grave manifestation of the disease, occurring comparatively rarely, and known as pernicious or progressive anæmia. Twenty-six years ago this disorder was described by Gusserow, but some time before this cases of the disease were reported and many others observed, but not published; in this country, for example, practitioners, more than thirty years since, met with instances of the disease presenting the grave symptoms which Gusserow and others afterward described, and which, by a sort of general consent, was given the title of puerperal anæmia.

The etiology of the affection is obscure; in some cases those affected have suffered from malaria, or were exhausted by rapidly recurring pregnancies, by obstinate vomiting, or by insufficient food; hæmorrhage, profound mental shock, and diarrhœa were also considered causes. Nevertheless, cases of the disease have occurred in which none of these factors were present.

Generally the disease begins gradually. The skin of the face grows paler and paler, and has a waxy appearance; in some cases the skin has a yellowish hue, but there is no emaciation, the weight, for a time at least, being retained; but after a time fever occurs, and then there is loss of flesh. Often there is anorexia. The more prominent general symptoms are palpitation of the heart, fainting, syncope, and headache; frequently sleeplessness is observed, but in some cases drowsiness. Hæmorrhages are not unusual, and the gums may be spongy and swollen, as in scorbutus.

Abortion or premature labor is a common occurrence, and in the latter case the fœtus is usually found to be dead. A fatal issue occurred in the majority of cases observed, though in some it was delayed for months.

In regard to the treatment, remedies addressed to the anæmic condition are, of course, indicated, but it is not necessary to enumerate them. A more important question arises in reference to the induction of abortion or of premature labor. Interruption of pregnancy was advocated by Gusserow, has received the indorsement of Charpentier, and more recently of Zweifel, but, on the other hand, is rejected by Kleinwächter, because of its hastening the commonly fatal termination of the disease. Chiara advocates an early induction of premature labor, or even of abortion, as in the obstinate vomiting of pregnancy. Tarnier observes that the epoch of intervention presents a grave question which is difficult to decide.

Varicose Veins.—Varicose veins of the lower limbs, or of the external genitals, or of the vagina, of the rectum and anus, are not very uncommon in pregnancy, though authors widely differ in their statements as to the frequency of this accident. For example, Budin asserts that twenty to thirty per cent. of pregnant women suffer from varicose veins, while Cazin makes the number one in twenty-one; and my own observations, made in the Philadelphia Hospital, are much more nearly in accord with the latter than with the former statement.

Among the alleged causes of varicose veins are increased quantity and changed character of the blood, gravitation, greater vascular tension, and pressure upon intra-abdominal veins by the enlarged uterus. Tarnier states that some authors have added to modifications in the circulatory apparatus, in explaining the occurrence of varices, those which take place in the nervous system under the influence of pregnancy. It must be confessed, however, that this etiology is not very obvious. Rupture of a varix in pregnancy may cause a rapidly mortal hæmorrhage, while such rupture in a varix of the vulva or vagina, taking place in labor, may result in the formation of a thrombus or hæmatoma, seriously interfering with the delivery of the child.

If the varicosities be large, all straining, or lifting heavy weights, taking long walks, and even being for a considerable time in the erect position, should be avoided; the subject must lie down a part of each day; moderate compression with a properly applied flannel bandage to an affected limb, especially if there be much œdema, as there frequently is, will be useful. The patient ought to be taught, in case there is threatened rupture of a varix, how to arrest hæmorrhage from it by direct compression.

Albuminuria.—Albuminuria is probably present in five to ten per cent. of pregnant women, although Dumas, uniting the statistics of Hippolyte, Abeille, Möricke, and Petit, finds that one in five or six thus suffers; Tarnier refers to the results recently published by Negri, Doléris, and Poucy, showing that the proportion of albuminurics is about five per cent.

A woman suffering with albuminuria may become pregnant, or another, being pregnant, may be attacked with nephritis; but in either case the albuminuria is an accident, independent of the pregnancy. On the other hand, however, there may be a nephritis which results from the pregnant state, the urine showing the presence of albumen, hyaline casts, and renal epithelium; but the disease disappears after the pregnancy. Various explanations have been given of the nephritis of pregnancy. Among these are the renal disorder which results from the increased work thrown upon the kidneys by the pregnant state, the greater vascular tension, pressure upon the renal veins by the enlarged uterus, similar pressure upon the ureters, and finally from reflex irritation, this irritation arising from the uterus and affecting the renal circulation and secretion. Leyden (*Zeitschrift für klin. Med.*, 1886) maintains that the lesions of the kidneys found in pregnancy nephritis do not correspond either to venous stasis or to acute nephritis, and attributes great importance in their production to arterial anæmia. According to him, this anæmia results from hindrance to circulation in the abdomen caused by the enlarged uterus, this hindrance increasing with the greater size of the organ of gestation. The cause acts mechanically by diminishing the quantity of urine, and hence albuminuria, and dynamically from lessening the supply of oxygen, and hence fatty degeneration of the kidney. Zweifel (*Lehrbuch der Geburtshülfe*, 1887) holds that of the many theories advanced in explanation of the disorder, only two deserve special mention, and yet neither has been proved. The first was proposed by Frerichs, and accepted by Bamberger, Leitzmann, Rosenstein, Lange, Hohl, Möricke, and others. According to this theory the renal changes are the result of increased intra-abdominal pressure, preventing the escape of the venous blood from the kidney, and thus causing engorgement of the organ. The other theory, that of Halbertsma, explains all the facts as resulting from pressure of the enlarged uterus upon the ureters. The former is accepted by Zweifel.

It is unnecessary to state the usual manifestations of albuminuria in pregnancy, nor the means by which a diagnosis is made. The most serious possible result is eclampsia; for while the majority of albuminurics are not eclamptic, it is very rare for eclampsia to occur in pregnancy unless the patient has albuminuria. Winter has recently called attention to premature detachment of

the placenta as a not uncommon accident in nephritic patients.

The treatment of albuminuria in pregnancy is governed by the same rules that apply to the management of the disease in the non-pregnant, except, probably, as advised by Tarnier, an absolute milk-diet, if the quantity of albumen in the urine be great, should be strictly enforced, and in some cases it gives remarkably good results; in some patients, the induction of premature labor or even of abortion may be clearly indicated.

Cardiac Disease.—It has been claimed that disease of the heart may result from pregnancy. Thus, admitting a normal hypertrophy of the organ caused by the pregnant condition, it is asserted that, as a consequence of rapidly recurring pregnancies, an ordinarily transitory hypertrophy becomes permanent. But this is only hypothetical. Further, as stated by Tarnier, Ollivier claims that subacute and chronic endocarditis may originate solely under the influence of pregnancy. However these questions may be decided, the obstetrician is concerned almost exclusively with cardiac disease which was present when the pregnancy occurred. Undoubtedly the pregnant woman, from the fact of her condition, is more liable to suffering, and even to danger, if she has valvular disease; the pregnancy becomes a complication in many cases, though not necessarily in all. Budin and others have shown that cardiopathics are peculiarly liable to abortion; Porak found that in 214 women who had disease of the heart, the pregnancy continued until term in only 126, while 88 aborted, or had premature labor. Whether premature or mature labor, or miscarriage occur, there is an increased liability to post-partum hæmorrhage. The treatment during pregnancy does not ordinarily differ from that required by cardiac disease in the non-pregnant condition. In some cases the induction of abortion or of premature labor may be indicated by the danger to the life of the mother.

Relaxation of the Pelvic Joints.—Some swelling and softening of the pelvic joints is one of the normal phenomena of pregnancy, but should these be excessive the mobility of the pelvic bones may become so great that it is impossible for the patient to walk, and, indeed, any movement of these bones may be attended with great suffering. The joint most liable to be affected by this abnormal relaxation is the pubic. The relaxation usually occurs in the latter half of pregnancy, but Moreau mentioned a case in which it appeared in the second month, and in this patient it continued for more than two years after delivery. Having begun, it usually increases until the end of pregnancy, when it gradually lessens and disappears in most cases. The most important treatment is rest; the more exercise is urged upon the patient, the more miserable she becomes through suffering and aggravation of the disorder. A prolonged rest, too, is required after labor, and when the patient gets up the immobility of the bones should be secured by a suitable apparatus. Barker states that in all cases he has seen this immobility has been effected by a little ingenuity in making and adapting a hip-binder of very strong, coarse cloth.

Neuroses.—Different nervous affections may occur in pregnancy, some of them indeed depending upon the pregnant condition. Among the latter may be mentioned neuralgic disorders, especially of the teeth.

Hysteria.—In most cases of hysteria the disease antedates the pregnancy, but in a few it seems to originate from it. While in a few cases hysteria has disappeared during pregnancy, in the majority it continues, sometimes becomes aggravated, and even insanity may follow labor. An interesting fact, observed by many, is that in some instances there is an almost, or quite, total absence of suffering during childbirth.

The treatment of hysteria in a pregnant woman is the same as if she were not pregnant.

Epilepsy.—If an epileptic become pregnant the disease may be mitigated by the pregnancy, but the attacks return with their original severity and frequency of occurrence subsequently; probably, however, a temporary favorable modification occurs in the majority of cases. In the rare instances in which the disease begins in pregnancy, it ceases after labor.

Chorea.—This is not a frequent disorder observed in gestation, for Barnes could find but fifty-six cases which had been published, and Fehling, in 1874, was able to add only twelve to this number. The liability to the disease is greater in primigravidæ than in multigravidæ; previous attacks of the disease create a predisposition to it; it may recur in several successive pregnancies, or be present in the first only. It usually begins in the first half of gestation, continues during the entire subsequent time, and in rare instances during the puerperal state. Wenzel's statistics show the mortality of the disease to be 27.3 per cent., and Spiegelberg found 23 deaths in eighty-four cases. The medical treatment need not be stated, for it is the same as when the disease occurs in the non-pregnant condition. The obstetric treatment, if the child be viable and the usual means for relief have been tried without benefit, and if the choreic movements are violent while the patient's strength is failing, is the induction of labor. Whether cases occur in which abortion is necessary is an undecided question.

Diseases of the Skin.—Duhring calls attention to the fact that in a few cases eczema, herpes, or pruritus may result from the pregnant condition, but they cease as soon as the pregnancy is over, and that chloasma is common; while, on the other hand, chronic affections, as eczema and psoriasis, are often observed to be much better during this period. In rare cases the pruritus is so severe that abortion has occurred. In three patients suffering with the disease who were seen by Cazeaux, the pruritus readily yielded to alkaline baths; Tarnier commends a solution of cocaine. Slocum has reported a case of *hirsuties gestationis.* The woman had been pregnant three times, giving birth to three children at term, "and with each gestation a growth of hair on the sides of the face, and under the chin, started at the beginning of the pregnancy and continued until childbirth, growing to the length of one and a half inch. As the catamenial function returned, the hair fell out, the face assuming its normal smoothness."

Acute Infectious Diseases.—Several observations have been made showing that when the mother suffers from a high temperature, the pulsations of the fœtal heart are increased in frequency and lessened in force, and interruption of pregnancy not unseldom occurs. The experiments of German observers seemed to prove that this interruption was due to the continued elevation of temperature; but the experiments of Charpentier, Doléris, and F. Doré, proved that if the increase was gradual, pregnant animals did not abort, nor was the life of the fœtus in the least compromised. Accepting these results, the conclusion must be, as Charpentier has stated ("Archives de Toxicologie," 1887), that hyperthermia does not exercise an important, only a secondary, influence in the production of abortion and the death of the fœtus, when the mother suffers with grave pyrexia, variola, scarlatina, rubeola, erysipelas, typhoid fever, etc.

The interruption to pregnancy occurring in infectious diseases has also been regarded as resulting from hæmorrhagic endometritis. The investigations of Slavjansky, for example, showed such condition in the cases of pregnant women attacked with cholera. But, on the other hand, Queirel, in his recent studies of the epidemic of cholera at Marseilles, took pains to seek for this endometritis, and he has not found it; he states that hæmorrhages have not occurred either in abortions or in labors, though he has frequently met with uterine inertia. Klotz, of the University of Innsbrück, studying the course of measles in pregnant women, in eleven cases of which there was interruption of pregnancy, endeavored to ascertain the causes of fœtal death not only in measles but in other infectious diseases, and concluded that hæmorrhagic endometritis was not proved anatomically in this disease, in scarlatina, in variola, in erysipelas, or in typhus.

Zweifel gives importance to the action of the "fever-blood" upon the nerve-centres causing uterine action,

great increase of temperature producing, as a rule, uterine contractions.

Probably, however, the most important factor in interrupting the pregnancy is, as asserted by Charpentier, toxæmia, the death of the fœtus resulting from this, and then its discharge from the uterus follows.

Typhoid fever may occur in pregnancy ; this condition, according to the statement of Murchison, and contrary to the opinion of Rokitansky and Niemeyer, furnished no exemption from the disease. In the great majority of cases, though the pregnancy is interrupted, recovery takes place.

Yellow fever is quite as likely to occur, according to Bemiss, in the pregnant as in the non-pregnant, but the liability to the disease is increased by childbed. Still referring to the statements of Bemiss, the liability to death is twice as great in pregnancy and in childbed. If the pregnant woman recovers from yellow fever, and gestation continues, the child is protected from the disease. The last statement certainly points to and strengthens the assertion previously made, that the usual cause of death in acute infectious diseases is toxæmia, that is to say, the specific poison of the disease passes from the maternal to the fœtal blood. It is not admitted that there is even a partial exemption from intermittent fever given by pregnancy ; where facts seem to sustain this view, their probable explanation is found in pregnant women not being so much exposed to the malarial poison. It seems to be tolerably well established that the fœtus may suffer from malarial poisoning, this condition being manifested by regularly recurring paroxysms of convulsive movements ; and in some of these cases the child at birth was found to be suffering from enlarged spleen. The administration of quinine is not forbidden by pregnancy, and if abortion or premature labor occur, the event is not to be attributed to the drug, but to the malarial intoxication ; nevertheless, it is possible that in some women there may be such idiosyncrasy that some other antiperiodic should be employed.

About sixty per cent. of pregnant women abort or have premature labor if attacked by cholera, though the recent statistics of Queirel, including 67 cases, show that in only 29 the pregnancy was arrested. The statistics just referred to also show that when the pregnancy was interrupted, the mortality was about sixty-six per cent., but if it continued, only fifty per cent. The death of the fœtus, probably, is usually due to toxæmia, as previously stated, or it may result from asphyxia.

Curschman claims that pregnancy causes a certain predisposition to variola. In varioloid there is little danger to the mother or to the fœtus, but in variola abortion or premature labor usually occurs, and is followed by the death of the mother. If a pregnant woman has variola, the rule is that the fœtus is also affected, and it may pass through all the stages of the disease in the uterus, but in some cases is born with the disease, and in others may be attacked soon after birth ; very rarely an apparently healthy mother gives birth to a child having variola, and the explanation proposed is that the mother had the disease without the eruption, and thus infected the child.

In some cases successful vaccination of a pregnant woman has rendered the new-born insusceptible to vaccination. Hence there is a stronger argument for vaccinating the pregnant woman if she is liable to be exposed to small-pox.

Scarlatina has been rarely observed in pregnancy. It is very liable to interrupt the pregnancy, and is peculiarly fatal. A similar statement may be made as to rubeola.

Pneumonia is a more frequent disease of the male than of the female, but in the female it has a one-third greater mortality, and is far more dangerous in pregnancy. The pregnant woman, if attacked with the disease, is liable to abort or to have premature labor ; this liability to interruption of the pregnancy is greatest the farther the latter has advanced ; after interruption the patient in most cases dies within two or three days, if recovery does not take place. Some have urged ending the pregnancy by artificial means, but the practice is not generally accepted, most authorities preferring the expectant plan of treatment.

Pleurisy usually terminates favorably, and does not disturb the pregnancy, but if the disease be double, or if bronchitis be associated with it, abortion or premature labor may result. Thoracentesis has been performed upon the pregnant woman without disturbing the gestation.

Jaundice ; Icterus Gravidarum.—This disease may occur in pregnancy in one of two forms—simple or malignant. The first, when it appears in the later months, is attributed by Frerichs to pressure of the enlarged uterus or of the colon distended with fæces, upon the bile-duct ; while Tarnier suggests that there is an icterus peculiar to pregnant women, and Peter regards it as arising from congestion of the liver ; Bedford has suggested that the disease may sometimes be in part due to mental emotions. The prognosis is favorable ; nevertheless, in rare instances that which was apparently the benign form of the affection becomes malignant. The malignant form of the disease, which is seldom seen, is dependent upon acute yellow atrophy of the liver, and usually causes abortion or premature labor, and has a fatal result. There have been occasionally epidemics of jaundice in pregnant women, gestation in many instances being arrested, the majority of those affected dying.

It has been been advised in malignant jaundice that the uterus should be emptied, but this rule has not been adopted ; certainly, if in a case of benign jaundice its future malignant character could be foreseen, the practice would be justifiable. So, too, it has been advised that in case of an outbreak of epidemic jaundice, security for pregnant women not yet attacked might be found in a change of residence.

Traumatism.—This includes injuries, and surgical operations in pregnancy. Very grave injuries have been received by pregnant women, and important surgical operations, such as removal of ovarian tumors, performed, and gestation has continued, while, on the other hand, comparatively trivial injuries have arrested it. According to Cohnstein, penetrating wounds of the abdomen usually arrest the pregnancy, though the uterus may not be injured. Operations upon the genital zone are very liable to disturb the pregnancy. A question of some importance is as to the repair of fractures in the pregnant woman, and a difference of opinion exists, some contending that this repair takes place as promptly as it would if she were not pregnant, while others, among whom Cazeaux and Tarnier may be mentioned, hold that there may be very great delay—the former narrating an instance in which a woman in the second month of pregnancy fractured the tibia, and consolidation failed to occur until after labor at term.

In three cases of gun-shot wounds—one case being reported by each of the following, Richard, Staples, and Hays—involving the uterus, the pregnancy was arrested ; in one a living child was born ; all the mothers recovered.

The simple rule in regard to operations in pregnancy may be founded upon the statement of Sir James Paget, that it would be mere recklessness to operate on a pregnant woman without good cause ; yet, if good cause for operation exists, she may be treated very successfully.

Chronic Infectious Diseases.—The statistics of the late Austin Flint and those of Gaulard show that a large percentage of women become phthisical during pregnancy or lactation. James, however, claims that pregnancy has a favorable effect, but that labor and lactation are undoubtedly injurious ; it would seem impossible to isolate the effects of labor from those of its preceding and following state, and really the conclusion is without practical value, save that the woman who has tuberculosis ought not to nurse her child, and this rule has been clearly shown by previous observations.

Pregnancy in the phthisical is rarely interrupted, even though the woman may be greatly exhausted by the disease ; the disease, when labor is over, usually pursues a more rapid course ; as might be expected, the children born of such mothers are in most cases feeble, and generally die early.

If the physician is consulted, it is his duty to earnestly advise against the marriage of a phthisical subject, whether maiden or woman.

Fournier holds that pregnancy is a complication of syphilis, complicating it by adding to it its own peculiar anæmia, its disposition to neuroses, its disorders of nutrition, etc. Abortion or premature labor is a very common consequence of the disease; thus, out of 414 pregnant women at Lourcine, in only 260 did the pregnancy continue until term. The secondary stage of the disease is that which furnishes the greatest liability to interruption of pregnancy, and from the fourth month to the end of the second year is the period during which a pregnancy is most liable to be arrested.

It is claimed by some, denied by others, that a syphilitic father may beget a syphilitic child, the mother remaining free from disease; yet, according to Fournier, who admits the possibility of direct paternal infection, the probabilities are that the child will not be infected. The most frequent source of infection is the mother. She may be syphilitic before conception, or she may acquire the disease just before, the fecundating being the infecting coition, or, finally, she may acquire syphilis during the pregnancy. Now, in the two first cases the child may be syphilitic; but in the third case, the infection taking place during pregnancy, it has been held that if this occurs after the middle of pregnancy the danger is very slight, and almost none if the mother becomes affected toward the end of normal gestation. Yet Tarnier refers to one instance in which the child was born syphilitic, though the mother did not become infected until the eighth month. The probabilities of the offspring being syphilitic are greatest in those cases in which both the parents are syphilitic. Should a syphilitic woman become pregnant, an antisyphilitic treatment must be employed, and so, too, if she becomes syphilitic during her pregnancy. If she is free from the disease, but is impregnated by a syphilitic man, ought this treatment to be pursued? The answer generally made is, not unless she has previously had pregnancies arrested presumably from syphilis.

Diseases of the Sexual Organs.—Pruritus of the vulva is sometimes met with in pregnant women. The application of a solution of borax in water, or in rose water to which morphia is added, as recommended by Meigs, or of cloths wrung out of hot water, generally gives relief. Other means are brushing the parts with a solution of muriate of cocaine, or of carbolic acid, or of chloral. Tarnier states that he has, in almost all cases, succeeded in relieving the pruritus by the employment of a solution of corrosive sublimate in the following formula: Corrosive sublimate, one part; alcohol, five parts; rose water, twenty, and water, two hundred and twenty-five.

Vegetations of the vulva may appear during pregnancy, and usually spontaneously disappear when the pregnancy is over. While, probably, in the majority of cases these growths are specific in origin, yet in some they may not be. Unless they are large and occupy so much space that they will interfere with the expulsion of the fœtus, active treatment during pregnancy is not advisable, for excision would be attended with considerable hæmorrhage, and besides the growths would soon be reproduced. The affected surfaces should be, so far as practicable, separated and kept clean; disinfectant and astringent solutions are to be applied. Tarnier speaks favorably of the application of a strong mixture of tannin and water, and Charpentier has seen the growths disappear by isolating the affected parts, and applying compresses dipped in Labarraque's solution.

Prolapse of the vagina, especially if cystocele be associated with it, may require the use of astringent injections and wearing an elastic ring pessary; for the latter, should it cause pain, a tampon of prepared wool to which a string is attached, dipped in a mixture of glycerine and tannin, may be worn during the day and removed when the woman retires.

Different forms of vaginitis may affect the pregnant woman, the chief of these being simple, granular, and specific; the two latter may be associated. In simple vaginitis, the most marked symptom of which is a leucorrheal discharge, bathing, cleanliness, antiseptic and mild astringent injections twice a day, will be useful; vaginal injections in pregnancy should be warm or tepid, and the fluid is to be used as a wash, not as a douche. Granular vaginitis, first described by Deville, in 1844, is characterized by the presence upon the surface of the vagina, especially at its upper part, of elevations about the size of a hemp-seed, so that the examining finger touches a rough, grater-like tissue, and by rather a profuse yellowish discharge which irritates the parts with which it comes in contact in passing out of the vagina. In addition to the means applicable to simple vaginitis, every other day a cotton or wool tampon, containing half a teaspoonful of powdered alum and the same quantity of subnitrate of bismuth, may be placed in the vagina; instead of this dry tampon one made of cotton first dipped in glycerine, and its surface freely covered with boric acid, may be employed; in either case the tampon is removed after twelve hours. Nitrate of silver injections also prove useful, or the diseased surface being exposed by a speculum, and then cleansed, is brushed over with the solution. Gonorrhœal inflammation of the vagina demands treatment in the interest of the child and of the mother, for the former, during its passage through the vagina may, by the contact of the infectious matter with the conjunctivæ, subsequently have a specific conjunctivitis, or the latter, from extension of the vaginitis after labor, have a salpingitis. Nitrate of silver injections here, too, are useful, but probably the most valuable remedy is corrosive sublimate, an injection of one part to three thousand of water being used at least twice a day.

In 1871 Winckel first described a form of vaginitis characterized by the presence upon the vaginal surface of a large number of transparent cysts, fifteen or twenty often being found upon a part the size of a dollar; most of these cysts contained gas, and when punctured collapsed with a sound quite audible; there was usually hypersecretion; he gave the disease the name of colpohyperplasia cystica.

Painless contractions of the uterus as one of the normal phenomena of pregnancy have been described; but under certain circumstances these contractions cause more or less severe suffering. If we admit with Wigand the existence of uterine rheumatism, the explanation of such suffering is in many cases quite simple, for it is the same in contractions of the uterine muscle as it is in the exercise of voluntary muscles affected by rheumatism. But most authorities do not regard the existence of uterine rheumatism as proved. The hypothesis of uterine neuralgia, or that of a metritis, has been suggested, or else we may say that in some women the gravid uterus is peculiarly sensitive to pressure, whether that be made from within or from without, as caused by fœtal movements, or by placing the hand upon the abdomen. There is, however, a form of intermittent pain in the gravid uterus resulting from injury, which apparently threatens premature labor or abortion, though neither occurs; and which has not been the subject of special consideration; two cases of this kind I have recently met with, one in hospital, the other in private practice. In the former a multigravida, at the beginning of the seventh month of pregnancy, fell, striking the front part of the abdomen upon a stove. As painful contractions of the uterus succeeded it was at first supposed labor was at hand, but there was no increased vaginal discharge, no effacement of the uterine neck, and no dilatation of the os. Though the uterine soreness and the painful contractions continued for two or three weeks, the pregnancy went to term, and the labor was normal. In the second case a multigravida, at the beginning of the seventh month, was lying in bed upon her back; one of her children, aged two years, was in the bed, and in his romping fell so that his head struck one side of the uterus. For several days she suffered severe intermittent pain in the uterus, but this pain, though the entire organ contracted during it, was referred exclusively to the side which had been struck. In each case the explanation of the suffering was that the normal and ordinarily painless contractions of pregnancy became painful because of injury to the organ. The treatment of such cases will be rest, opium, and the ap-

plication of warm compresses to the abdomen; occasionally a mild counter-irritant may be required.

Various positional disorders of the gravid uterus may occur—prolapse, anteversion, anteflexion, retroversion, and retroflexion—the gravest of these being complete

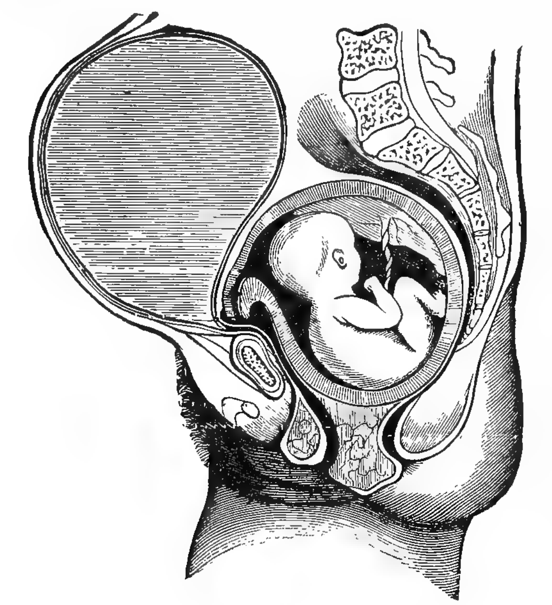

Fig. 3095.

prolapse and the posterior displacements; in addition to these there may be herniæ of the organ.

In prolapse of the uterus the organ may descend to the pelvic floor, and may partially or entirely protrude from the vulvar orifice; should the latter occur the prolapse is called complete. In most cases the patients are multigravidæ; in some the accident occurs gradually, in others suddenly, in consequence of a violent effort, as lifting a heavy weight; and in rare cases impregnation of a prolapsed uterus has taken place; there have been instances where prolapse of the uterus has occurred during labor; in some of these the labor was spontaneous, in others it was artificial, the accident taking place, for example, during extraction with the forceps.

Visual, digital, and bimanual examination will readily recognize this positional disorder of the uterus and its degree, care being taken to avoid mistaking hypertrophic elongation of the cervix for this displacement.

The consequences of prolapse of the gravid uterus may be very serious. There is great liability to interruption of the pregnancy, and in rare instances incarceration of the organ occurs, having similar grave results to those which will be referred to in connection with this accident in posterior displacements.

The question as to whether the pregnancy in a completely prolapsed uterus can continue until term, has received different answers, eminent German authorities, such as Schroeder, Gusserow, and Zweifel, asserting that no authentic case of this kind has ever been reported; while some French authorities, among whom may be mentioned Charpentier and Tarnier, hold the opposite; the statement of the former seems the more probable.

If prolapse occur in pregnancy an effort should be made to restore the uterus to its normal position and to keep it there; after its restoration the patient ought to remain in the horizontal position until danger of the recurrence of the accident is improbable. If the organ be irreducible, and serious difficulties are present, especially incarceration, there must be no hesitation in producing abortion, and after this has occurred the restoration of the organ is to be made.

Anteversion, or anteflexion, of the pregnant uterus is a less frequent, and usually a less grave, accident than the corresponding posterior positional disorders. Should either of the first two accidents occur in the early months of pregnancy, the progress of gestation gradually rectifies it in almost all cases. In the late months of pregnancy there may be in the multigravida, in consequence of great relaxation of the abdominal wall, marked projection of the uterus in front, causing the woman more or less inconvenience and discomfort; the relaxation may be so great that the anterior wall rests upon the thighs when the subject is standing. Lying upon the back as much as possible, and, when the woman is up, wearing a suitably applied bandage, constitute the proper treatment of this accident in the latter part of pregnancy.

Should incarceration of the gravid anteverted or anteflexed uterus happen, an accident possible only in the early months, and which has a predisposing cause in increase of the antero-posterior diameters of the pelvis, the fundus of the uterus is fixed behind the pubic joint; but manual reduction can usually be readily effected. For this reduction the patient is placed in a horizontal position, the hips somewhat higher than the head; then an effort is made, by drawing upon the cervix and pressing upon the anterior wall of the uterus, near the fundus, to restore the organ to its normal position; or pressure may be made with the index and medius introduced into the vagina upon the body of the uterus. "Godefroy placed the index of one hand in the vagina, the other in the rectum, and effected reduction by pressure in opposite directions; while Moreau drew the neck down by a finger in the vagina, and pushed up the fundus by means of a sound in the bladder."

Posterior version or flexion of the gravid uterus is a more frequent and grave disorder, if it should not be rectified by nature or by art. These names are frequently used synonymously, and indeed it is asserted that a pure retroversion of the gravid uterus is rarely met with, some flexion usually being combined with it. Nevertheless, it

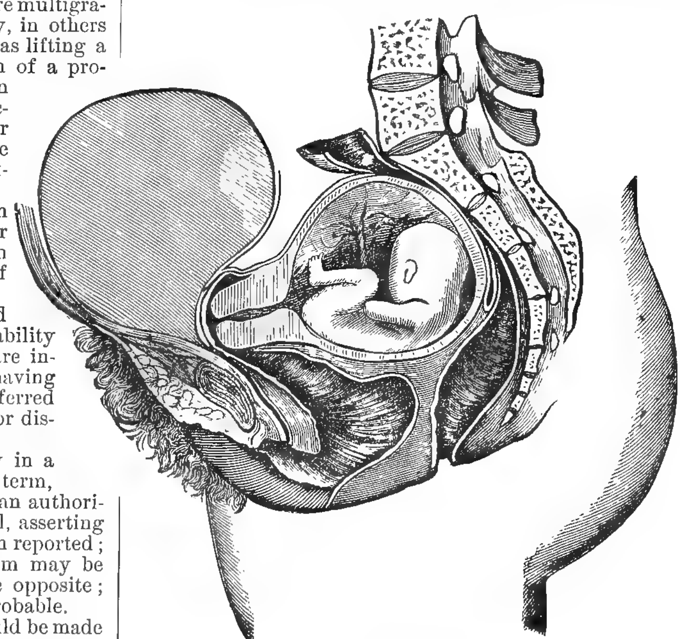

Fig. 3096.

is probable that a woman whose uterus is retroverted rarely becomes pregnant, and hence, if the gravid uterus is found retroverted the accident almost certainly occurred after impregnation; and on the other hand, a

woman with retroflexed uterus may become pregnant more frequently than one whose uterus is in normal position, because the deviation is frequently the cause of abortion. In retroversion the axis of the cervix corresponds with that of the body of the organ, while in retroflexion it forms an angle—acute, right, or obtuse—with the uterine axis. The preceding illustrations, the first of flexion, and the second of version, show the essential difference between the two. In regard to retroversion of the gravid uterus, there has been much dispute as to whether the deviation is sudden or gradual, and as to whether distention of the bladder is cause or consequence. It may be admitted that each form of deviation can occur, that is, it may be sudden or gradual, and that distention of the bladder is occasionally a cause, while in all cases it is one of the gravest consequences of the change of position.

In the majority of cases of these positional disorders of the gravid uterus, spontaneous rectification occurs in the progress of pregnancy. In very rare instances, however, of retroflexed uterus, as first suggested by Merriman, and as confirmed by the observations of Oldham and Stillé, pregnancy may go to term or near it, though the uterus remains retroflexed.

In some cases, again, spontaneous abortion is not an infrequent result. But should neither spontaneous nor artificial restoration be made, nor abortion occur, incarceration follows, for the unusual development of the uterus observed by Oldham and by Stillé is so rare an event that it may be omitted from consideration. When the uterus remains imprisoned, there will result retention of urine and obstruction of the rectum; uræmia and local or general peritonitis may occur; the bladder may rupture, or there may be a simple or a diphtheritic cystitis, and, as a consequence, detachment of the whole or of parts of the vesical mucous membrane. Valenta has reported a case in which retroflexion caused in the fifth month gangrene of the bladder, perforation into the small intestine, and death.

In making the diagnosis the bladder should be first emptied by the catheter if possible, but, if this be impossible, especially in case there be great accumulation of urine, by the aspirator; if the patient is very sensitive an anæsthetic must be employed. Given the probable fact of pregnancy, its certain proof may usually be had from auscultation in case the pregnancy has advanced to four months or more. Then by examination with the finger, both vaginal and rectal, by abdominal palpation, and finally by combining the latter with vaginal touch, the fact of retroversion or retroflexion of the uterus will in most cases be clearly established.

The diagnosis of the deviation having been made, the next step is to correct it, and prevent its return. Supposing the simplest form of the disorder, a displacement at two or three months being present, and the uterus be mobile, its correction can generally be readily made by the bimanual method, and the return of the disorder be prevented by the application of a suitable pessary, which in most cases ought to be worn until the end of the fourth month. Even if the uterus be almost, or quite immobile, and no grave consequences of the displacement be yet present, its gradual restoration may be possible. In attempting such restoration the patient takes the knee-chest position and then the operator introduces the large blade of a Sims's speculum, pressing the point of the blade as far up as possible in the posterior cul-de-sac. By this pressure upon the posterior wall of the uterus, we endeavor to lift up the organ while retracting the perineum; the movement of the uterus may be assisted by hooking a tenaculum into the vaginal cervix, which is thus drawn backward and downward. The operation may be repeated for a brief time each day, should no unfavorable symptoms arise; there may be very slight gain each time, but patient perseverance will, in many cases, be rewarded with complete success. If, however, symptoms of incarceration are manifested, immediate restoration must be attempted. In such cases an anæsthetic will usually be required, and therefore the knee-chest position cannot be taken while efforts at restoration are made. Indeed, such position would hinder rather than assist return of the organ to its normal place in some degrees of this displacement; for example, in case the fundus of the uterus has descended, so as to be near the vaginal outlet, and the cervix is directed above the pubic joint, the organ occupying a position corresponding nearly with the axis of the pelvic inlet, the cervix being highest, it is manifest that there would be, so far as the action of gravity and atmospheric pressure are concerned, force exerted which would increase rather than lessen the displacement. Under such circumstances it is better for the patient to be lying upon her side, or upon her back. The four fingers of one hand may be introduced into the vagina to press the organ up, or two fingers applied to the anterior surface of the neck, now its superior, to draw this part downward and backward, while two of the other hand are placed in the rectum and the body of the uterus is by them pushed upward and forward. It is doubtful if the colpeurynter, whether introduced into the vagina or into the rectum, is of much value.

If the organ cannot be restored to its normal position, and serious symptoms are present, the only resource is to empty it, that is, produce abortion; and in those cases in which it was impossible to reach the os, for the introduction of a sound, puncture of the uterus, thus evacuating the amniotic liquor, has been successfully employed.

Herniæ of the Uterus.—Herniæ of the gravid uterus are rare. In some instances protrusion of a part of the organ may take place in an umbilical hernia, or again there may be a ventral hernia, the integrity of the abdominal wall having been lost from the distention of a previous pregnancy, or from an injury, the separation usually being between the recti muscles. The conditions which have been mentioned rarely give rise to serious difficulty during pregnancy, or in labor; nevertheless in the latter, if a considerable eventration is present, the uterus thus being withdrawn from the assisting action of the abdominal muscles during the second stage, that stage will be tedious, and an instance of this kind I have known. The comfort of the patient during pregnancy will usually be promoted by a suitable bandage.

The only other forms of herniæ known are inguinal and crural. Eisenhart states that hernia of the gravid uterus is nearly as rare as that of the non-gravid, and the slight preponderance in number of the former is probably due to the fact that pregnancy directs attention to a condition that would be otherwise unnoticed. In some historical references this writer states that Nicolaus Pol (1531) reported the first case; Cæsarean section was performed, the mother surviving three days, but the child lived until it was a year and a half old. In 1610 Sennert operated on a case, the mother living twenty days, and the child until it was nine years and a half old. Saxtorph's and Ledesma's cases are next given, that of the latter occurring in 1840. Rektorisk reported a case in 1860; the Cæsarean operation was done, the mother died, but the child lived.

Inguinal hernia has been frequently observed with uterus bicornis or didelphys. In Winckel's case, reported by Eisenhart, the uterus was bicornis; the hernia, which involved the right horn, occurred suddenly in the fourth month of pregnancy. Scanzoni has reported a case of inguinal hernia in a patient who had two pregnancies in one year, one of these being ended by spontaneous and the other by artificial abortion.

In either crural or inguinal hernia, Winckel advises abortion; but if the fœtus be viable, the Cæsarean section should be done at the end of pregnancy, and after the operation the uterus is, if possible, to be restored to the abdominal cavity; but if this cannot be done it should be extirpated.

Structural Diseases of the Uterus.—Two only of these will be considered, benign and malignant growths. Fibroids, or myomatous tumors of the uterus are comparatively rarely observed in pregnancy, for such tumors cause a relative sterility; thus, while the average sterility of women is one in eight, that of those suffering from such neoplasms is one in three. These tumors usually increase in size and become softer in pregnancy, and after this a par-

tial atrophy is frequently observed, more especially in those which have a predominance of muscular tissue in their structure.

Stratz (*Zeitschrift für Geburtshülfe*) has recently reported the results of 11 cases of uterine myomata observed in pregnancy. In 4 spontaneous abortion occurred, and in 3 it was induced; twice the tumor and the uterus were removed, and twice also the tumor only was taken away, once by laparotomy, and once through the vagina, and in the two latter cases only were living children born at term; all the mothers recovered. On the other hand, of 13 women in whom the tumors were discovered during labor, 7 died, and 8 of the children were saved. Hence he draws the conclusion that intervention during pregnancy is much more favorable for the mother, while delay until labor occurs is more favorable for the child. Recognizing the fact that the mother's is more valuable than the child's life, Stratz holds that intervention during pregnancy ought to be the general rule; that in very many cases abortion should be produced, as the sole rational measure, since myomotomy is yet too recent an operation for its true value to be known. But it should be remembered that whether a fibroid is a serious complication of pregnancy depends upon its size and position; growths of moderate size, unless so situated that they notably lessen the size of the birth-canal or seriously interfere with the expansion of the lower segment of the uterus, may not prevent normal labor; and such growths, as the experience of most practitioners will testify, are those which are most frequently observed. If the fibroid is situated at the uterine fundus, abortion is very liable to occur. In many instances where the growth was in the lower part of the uterus or in the cervix, and submucous, it was successfully extirpated during labor. If the tumor be subserous, and not so large that it prevents the development of the uterus, there is no indication for interference; on the other hand, its removal is indicated if it be large, and then, in case it be pedunculated and without extensive adhesions, that removal is not difficult, nor likely to be followed by interruption of the pregnancy.

If the fundus of the uterus be affected by cancer or by sarcoma, pregnancy is not at all probable, and should it happen, abortion is inevitable. Malignant disease of the cervix, however, is not so invariable an obstacle to impregnation. Nevertheless, it is a comparatively rare occurrence that a woman who has cancer of the womb becomes pregnant; the statistics presented by Stratz, *op. cit.*, show that in 1,034 cases conception was observed in only 12.

Pregnancy causes the more rapid growth of malignant tumors of the uterus, and extirpation of the diseased structure, although the operation may cause abortion, is plainly indicated.

If an ovarian tumor is small it rarely interferes with pregnancy, and, therefore, the statement made by Stratz is too absolute, that the occurrence of pregnancy in a woman having such a growth is a sufficient indication for at once performing ovariotomy. But should the tumor, either by size or position, interfere with the progress of the pregnancy, ovariotomy is indicated, and the earlier in gestation the operation is done the more favorable the prognosis. In fourteen cases of ovarian tumors complicating pregnancy, reported by Stratz, ovariotomy was done; all the mothers recovered, and thirteen out of fifteen children were saved, abortion occurring in two cases, and there being one twin pregnancy. These results are very much better than those following the expectant plan, the induction of abortion, or puncturing the cyst.

Mastitis, ending in resolution or in suppuration, has occasionally been observed during pregnancy, but the treatment of this affection does not require special consideration. There is a normal hypertrophy of the mammæ in pregnancy; but in rare instances this hypertrophy becomes very great, transgressing all physiological bounds, and in such cases abortion is liable to occur; usually the hypertrophy is followed by atrophy when the pregnancy is over. Treatment—including the application of support to the enlarged breasts, of iodine, or of cold, and of compression, and the internal administration of the potassic iodide—has rarely proved of notable value.

Tumors of the breast, whether benign or malignant, usually increase rapidly in size during pregnancy; in a few instances malignant growths begin at this time. If mammary cancer is complicated by pregnancy, or originates during it, extirpation of the growth is indicated.

Diseases of the Ovum.—There will be included in this class anomalies of the amnion, the chorion, the deciduæ, and of the placenta and cord, diseases of the fœtus having been elsewhere considered in this work.

Amniotic Adhesions and Bands.—Adhesions between the amnion and the fœtus and amniotic bands are in some instances met with. These were supposed by some observers to result from inflammation of the amnion, amniotitis; but the hypothesis now most generally accepted is that adhesions are caused by an arrest of development, and that bands uniting the skin of the fœtus, or, in some instances, floating in the amniotic liquor, either unattached or attached only at one end, result from stretching the adhesions through an increase of

FIG. 3097.—Amniotic Adhesions and Bands. (Charpentier.)

the amniotic liquor. Deformities of the fœtus may be caused by these anomalies, and, in some instances, amputation of a limb, or part of it, may be effected by an amniotic band.

Polyhydramnios; Oligohydramnios.—By the former—commonly called hydramnios—is meant excess, and by the latter deficiency, of the amniotic liquor. Whenever the amniotic liquor is in marked excess of two quarts, there is said to be polyhydramnios; in some instances this excess is between twenty and thirty quarts. The affection is more frequent in multigravidæ than in primigravidæ—according to McClintock, 23 to 5; more frequent in twin than in single pregnancies, and generally in the former the twins are of the same sex; and in some cases there is polyhydramnios in one fœtal sac, oligohydramnios in the other; in a few instances polyhydramnios has been found in extra-uterine pregnancy.

The disease has been attributed to amniotis, to persistence of the vasa propria of Jungbluth, which usually become obliterated in the last months of pregnancy, to great activity of the renal function of the fœtus, to transudation of serum of the maternal blood through the fœtal membranes, and to transudation from the fœtal circulation.

Two forms of polyhydramnios are met with, the one chronic, the other acute; the former is much the more frequent. In the chronic affection the dropsical accumulation takes place slowly, and is, therefore, better tolerated; but in the acute disease the accumulation is very rapid, and fever is present. Tarnier distinguishes the last form of the affection as primary or secondary; by

the latter is meant an acute form grafted upon the chronic.

The most striking characteristics of polyhydramnios are the rapid increase in size of the uterus—the organ at five months, for example, being as large as it should be at the end of pregnancy—and the very distinct fluctuation. Besides these we have pressure-accidents relating to respiration and circulation, the former becoming difficult, so that the patient must be erect or sitting; and from interference with the latter there may be general œdema, but there always is œdematous swelling of the lower limbs; the uterine walls, both by abdominal and by vaginal examination, are found tense and resisting, and obstetric palpation and auscultation are difficult, or may even yield negative results so far as clearly establishing the diagnosis of pregnancy; vaginal examination shows the os high up, and a tense, elastic mass, in some cases giving distinct fluctuation, is found blocking up the pelvic inlet; the neck may be partially or completely effaced.

The induction of labor is clearly indicated if the uterine distention be so great that the life of the mother is in peril. The obstetrician must remember that there is great liability to post-partum hæmorrhage from uterine atony, and must guard against this accident.

Oligohydramnios may, according to some, cause adhesions between the fœtus and the amnion, and the subsequent formation of amniotic bands by stretching these adhesions when the amniotic liquor becomes abundant: a more probable explanation of these conditions has been given. But it seems not doubtful that in those cases in which this fluid is scanty, the fœtus cannot have its normal attitude, and undergoes injurious compression from which deformities may result.

Diseases of the Chorion.—Cystic Mole, or Hydatidiform Degeneration of the Chorial Villi. This is an affection of

Fig. 3098.—Cystic Mole. (Charpentier.)

the chorial villi, but whether these are primarily or secondarily involved has been a matter of dispute. Hecker asserted that it arose from failure in the development of the allantois, but this view, though strengthened by the absence of blood-vessels in the walls of the vesicles, is not generally accepted. Lesions of the decidua are present, and these in most cases follow the change in the villi; but sometimes, according to Virchow, endometritis precedes the chorial disease, and may contribute to it. The arguments in favor of the maternal origin of the disease are its frequent recurrence in the same woman—thus Depaul reported the case of one patient who thus suffered in three, and Mayer, one who had the disease in eleven pregnancies—and its occurrence in women advanced in years—for example, Schroeder saw it in one woman fifty years of age, and in another fifty-three years of age. On the other hand, instances of twin pregnancy, in which one ovum was diseased and the other healthy, have been observed, and such facts strongly indicate the fœtal origin of the malady.

The generally accepted view of the nature of this affection is that proposed by Virchow, who believes that it arises from a myxomatous degeneration of the chorial villi. The part affected by this change is converted into a vast number of cyst-like formations—there may be five or six thousand; these vary in size, some being as large as an almond, others as small as, or smaller than, a currant, and still others scarcely visible to the unaided eye. Depaul states that they vary in size from a pin's head to a pullet's egg; they have pedicles, but these are not attached to a common stem, as is seen in a bunch of white currants, or of grapes, to which their appearance has been compared, but to other vesicles. The semi-fluid substance in the vesicles is similar to that found in Wharton's jelly; it is composed of water, albumen, mucine, salts, chloride of sodium, and phosphoric acid (Fig. 3098).

If the disease begins before the formation of the placenta, the entire chorial tissue will be involved, but if after, the disease is limited to the placenta chiefly, and in some instances to a part of it.

The affection is rare, Madame Boivin having met with but one case in 20,375 deliveries.

Depaul has presented three important signs of a cystic mole: 1. A more rapid enlargement of the abdomen than is seen in normal pregnancy. In one of his patients the uterus was four fingers' breadth above the umbilicus at four months. 2. Attacks of uterine hæmorrhage. This symptom has occurred as early as the forty-fifth day, and, on the other hand, has been delayed as late as the fourteenth month. Discharges of blood in some cases alternate with discharges of a watery fluid. 3. The expulsion of separate vesicles, or of clusters; of course this sign is conclusive. The danger to the woman is exhaustion from repeated hæmorrhages, or a single hæmorrhage may be so great as to be fatal. The fœtus in almost all cases dies. Nevertheless, there are instances in which an "hydatid" mass has been expelled, and the pregnancy continued until term, when a healthy child was born. Such cases were probably examples of a twin pregnancy in which myxomatous degeneration affected one ovum, which was discharged, while the other remained healthy.

No active treatment is required until hæmorrhage occurs. If this be slight, rest, cold acid drinks, and an opiate may be sufficient. Even if the disease be proved by the expulsion of the so-called hydatids, it does not follow that the uterus is to be at once emptied. The dominant fact guiding the treatment is hæmorrhage. If this persists, if it is grave, and only temporarily restrained by the tampon, the os uteri should be dilated, the uterine cavity emptied, and hæmostasis secured by proper means.

Destructive Cystic Mole.—Zweifel describes, under the designation *Die destruirende Blasenmole,* rare cases, of which only three have been observed—one each by Volkmann, Waldeyer, and Kriger—in which the chorial villi grow so rapidly into the uterine wall that they reach the peritoneal covering, and hence this wall becomes greatly weakened. The difficulty in removing such a growth, the impossibility of making the removal complete, and the liability of causing rupture of the uterus, are obvious; but without such removal the hæmorrhage cannot be arrested. Two of the three cases that have been reported died from hæmorrhage, and the third from peritonitis. Where interference is necessary, Zweifel advises dilatation of the os by a compressed sponge that has been thoroughly disinfected by hot air; expression of the

uterine contents may be tried, and if this fails, the hand must be introduced into the uterus and the curette then employed, this operation being followed by washing out with antiseptic injections the parts detached.

Myxoma of the Membranes of the Ovum. In addition to the "partial hyperplasia of the fœtal connective tissue in the chorial villi, the cystic mole, Breslau and Eberth have found a similar hyperplasia in the parts of the chorion without villi. This appears in the form of a soft gelatinous thickening of the membranes, and during labor it feels like the scalp distended by serous infiltration" (Zweifel).

Fibrous Myxoma of the Placenta. This degeneration was first described by Virchow, who gave to it the name of fibrous myxoma of the placenta. The growth is composed of mucous and fibrous tissue; it is vascular, but there are no vesicles as in cystic degeneration of the chorial villi. In some cases there is a single large tumor, as in one reported by Storch, in which the mass was five inches and a half long, and three inches and a half broad; but in other instances there is a large number of small tumors.

Decidual Endometritis.—Four varieties of this affection have been described.

1. *Diffuse Decidual Endometritis.* This usually affects only the uterine decidua, decidua vera; there is thickening of the membrane from proliferation of the decidual cells, and development of the connective tissue; it is also asserted that the subjacent muscular fibres may undergo hyperplasia.

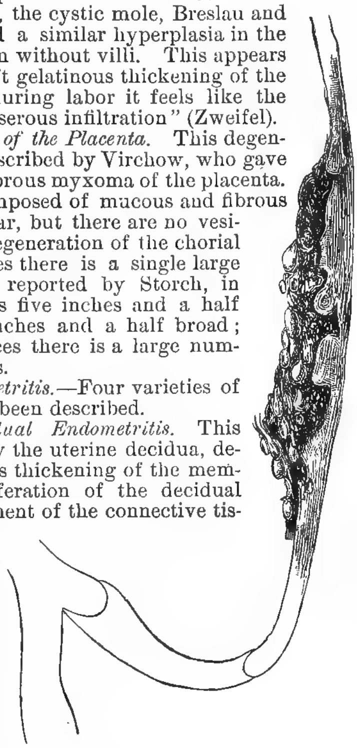

Fig. 3099.—Destructive Cystic Mole.

2. *Polypoid Decidual Endometritis.* This is characterized by thickening of the decidua vera, and polypoid growths, irregular in form, broad-based, and about three-fourths of an inch in height (Fig. 3100).

Breus states that if polypoid endometritis occurs early, the inflammatory process readily extends to the chorial villi, with consequent atrophy of the ovum and abortion; upon the aborted ovum there will be found the proofs of diffuse and polypoid decidual endometritis.

3. *Cystic Decidual Endometritis.* In this form of the disease not only the decidua vera is involved, but also the glands; obstruction of the gland-ducts results from inflammatory swelling, and cysts are formed—in other words, they are retention-cysts.

4. *Catarrhal Decidual Endometritis.* The characteristic evidence of this disease is the discharge from time to time of a watery fluid, known as hydrorrhœa gravidarum. This discharge, which may occur as early as the third month, but usually not until the late months, of pregnancy, is more frequently observed in multigravidæ than in primigravidæ; it is albuminous, generally yellowish, and may contain blood. Many of the cases of supposed rupture of the membranes and discharge of the amniotic liquor days and even weeks before labor, are really instances of hydrorrhœa, a discharge of so-called false waters occurring. Slight pains commonly accompany the discharge; in most cases it is repeated several times. Premature labor rarely follows hydrorrhœa, but its possible occurrence suggests that the patient, especially if there are uterine contractions, should lie down, and decided pain indicates the use of opium either by rectal injection or by the mouth. The causes of decidual endometritis are not well known. In some cases it is apparently the result of syphilis, and in others of violent bodily effort, or of excessive work; in others it existed prior to the pregnancy, and in still others follows the death of the fœtus.

Decidual Hæmorrhage.—Extravasation of blood may take place involving all the deciduous membranes; "if the extravasate is situated in the serotine membrane it may extend between the reflexa and the chorion, invaginating the latter and the amnion into the cavity of the ovum, and the embryo, if not previously dead, dies from compression;" sometimes even the cavity of the ovum is ruptured and the effusion penetrates into it. If the ovum is not ruptured the amniotic liquor is absorbed after the death of the embryo, and the latter disappears, the ovum containing only the remains of the cord. If expulsion of the ovum occurs soon after the hæmorrhage, the mass is composed chiefly of a large clot of blood, and has been called a blood mole. If, however, the expulsion be delayed, the embryo having prematurely escaped, or having undergone absorption, the effused blood has become more firm, and regressive metamorphoses having taken place, the mass is known as the fleshy mole. In either case the pregnancy has been called a false or molar pregnancy, and the mass expelled a blighted ovum (Fig. 3101).

Placental Apoplexy.—Jacquemin has described three forms of placental hæmorrhage. In the first the blood is infiltrated in one or several lobes of the placenta; in the second it occupies an irregular cavity which presents projections in different directions; but in the third there are regular and circumscribed cavities, varying in size from a hemp-seed to a pigeon's egg; these effusions are usually multiple, and at first appear as blood-red extravasates, but afterward lose their deep hue and become grayish-red, or yellowish-white, fibrin-like masses. According to Kleinwächter placentitis is the usual cause of these hæmorrhages.

When the effusions are multiple or large, they may so seriously interfere with the nutrition of the fœtus that its death results.

Placentitis.—According to Hegar and Maier, inflammation of the placenta may originate as a cell proliferation of the decidual tissue, or from the larger fœtal arteries; it soon terminates in induration; in some cases it results in strong adhesions between the placenta and the uterus, requiring at labor manual detachment of the former. The

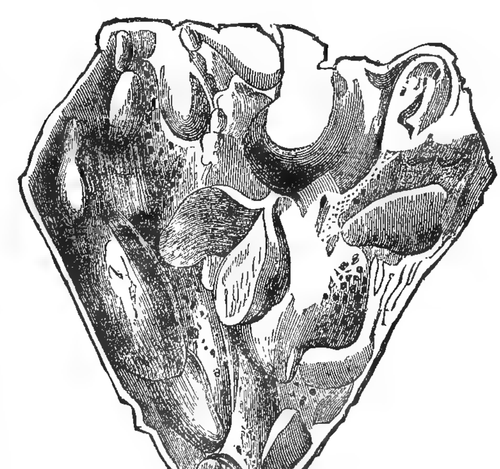

Fig. 3100.—Polypoid Decidual Endometritis. (Charpentier.)

formation of pus is, according to Zweifel, exceedingly rare, and can only be ascertained by the help of the microscope.

Calcareous and Fatty Degeneration of the Placenta.—The presence of sand-like grains either upon or in the maternal or the fœtal portion of the placenta is not uncommon; in some cases the calcareous products may present

the form of needles or of scales. The presence of these formations is without importance.

Fatty degeneration has been described by Barnes "as generally partial, invading one or more cotyledons, or part of them, forming in many cases diseased masses imbedded in comparatively healthy tissue, thus giving evidence that it originated during the life of the fœtus. In some instances we find, indeed, a living fœtus with a placenta in part affected; in others we find the disease more advanced and the fœtus dead, but with some healthy placenta, the vessels still containing blood. To the naked eye the fatty placenta may exhibit masses of a yellowish pale color, more solid than the spongy, healthy tissues surrounding them, and easily friable." Among the consequences of fatty degeneration is abortion. Barnes holds that this change may explain some cases of hæmorrhage during gestation which are attributed to placenta prævia.

Tumors of the Placenta.—Cystic and solid tumors of the placenta are sometimes met with; one variety of the latter has been previously mentioned. Klotz has recently (*Archiv für Gynäk.*, Band xxviii.) described adenoma of the placenta. This tumor originates in the spongy portion of the placenta or in the glandular cavities of the serotine decidua. Adenoma of the placenta causes the

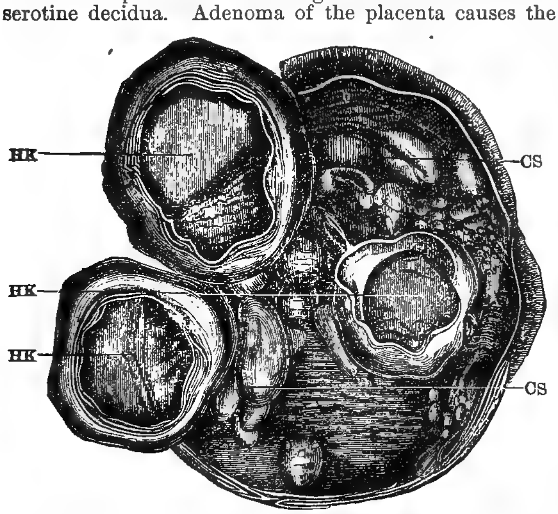

FIG. 3101.—Hæmorrhagic Mole. CS, blood-clots; HK, hæmorrhagic cysts. (Charpentier.)

death and the expulsion of the fœtus, and this is followed by retention of the placenta, the retention lasting for weeks, and even months.

Syphilis of the Placenta.—The following are the microscopical appearances of placentæ from syphilitic mothers, as given by Zilles in his valuable monograph, *Studien über Erkrankungen der Placenta und der Nabelschnur bedingt durch Syphilis* (1885): The placenta is of massive development and of great weight, in comparison with the imperfect development of the fœtus. The general color of the organ is pale red, but in the diseased portions yellowish-white. Here and there the tissue is firmer, more resistant, compact, and friable than the normal placenta. At various points gummatous nodules are found; they are wedge-shaped, nodulated, fibrous formations, with their bases in the decidua, but they generally grow smaller as they penetrate more deeply into the fœtal placenta; they vary in size, some being as small as a pin's head, others as large as a walnut; in some instances they occupy circumscribed portions of the entire thickness of the placenta. The gummata upon section show a structure of concentric lamellæ; the external layers are firmer, more like fibrous tissue, and have a grayish-yellow color, while in the centre there is a yellowish-red, or orange-yellow, cheese-like, soft or fluid material. Scattered through the peripheral zone are nodules of a cloudy orange-yellow color and cheesy in character, about the size of miliary tubercles. If complete degeneration of the central portion has occurred, an irregular cavity is present, its walls being formed of fatty, granular débris, and covered with pus-corpuscles. The decidua at the uterine surface is greatly thickened, cloudy, and presents yellowish-white spots. If the fœtus is affected, nodules, similar to those previously described, are found under the amnion. The umbilical cord is firmer than normal, and upon section a remarkable crescent-shaped thickening of the vessels can be seen with the naked eye. There are also seen the characteristic nodules in the tissue of the cord at some distance from the vessels.

Anomalies of the Cord.—Coils of the Cord about the Fœtus or its Members. One or more loops or "circulars" may be around the fœtus, or one of its members; the part most frequently thus encircled is the neck, and in one case that has been reported the cord was wound around the neck eight times. This accident occurs more frequently in multigravidæ than in primigravidæ, and is oftener found with the male than with the female fœtus. In general no injurious result follows such position of the cord, but in some cases the calibre of the umbilical vessels is materially lessened, and death of the fœtus ensues.

Knots.—Accumulation of Wharton's jelly at particular parts of the cord, causing there a notable projection, is known as a false knot. But a true knot is formed if the fœtus passes through a loop in the cord; such a knot is met with once in two hundred cases; the knot is in some cases double, and in others, instead of either one single knot or a double knot being present, there are several single knots. Depaul, for example, saw a case in which there were five. The knots are recent, or old; in the former, which occur during delivery, the diameter of the cord is normal, there is no lessening of Wharton's jelly; but in the latter the knot is smaller, Wharton's jelly being notably lessened. If the knots are contiguous, and are formed during pregnancy, it is possible, according to some authorities, that they may be drawn so tightly that the circulation is seriously interfered with and the fœtus dies; but ordinarily the circulation is not interrupted from this cause.

Torsions.—The umbilical cord normally presents torsions, this twisting being, in by far the larger number of cases, from left to right. But there may be an excessive number of these torsions; Dohrn saw a case in which there were 85, Meckel 95. They have been more frequently observed in the case of the male than in that of the female fœtus, the proportion being 8 to 5. Spiegelberg described them as præmortal, and postmortal; the first are usually caused by the movements of the fœtus, but the second by those of the mother. Dancing is mentioned by Kormann as a cause of twists in the cord. Torsions are most numerous near the umbilicus, and next in the vicinity of its placental attachment. In some instances division of the cord has followed torsions, the fœtus thus being left free in the uterine cavity; in rare cases occlusion of the vessels or great stenosis has been thus caused, and of course in either condition the fœtus dies.

Stenoses of the Umbilical Vessels.—Narrowing of the vessels of the cord may occur independently of knots or torsions. These stenoses, first observed by Oedmanson and Winckel, and described by Birch-Hirschfeld, are usually found in the vein near the placenta. The latter also found circumscribed stenoses of the arteries in the vicinity of the umbilicus, and also near the placenta; he regards them as resulting from syphilis. Spaeth states that atheromatous changes may occur in the arteries. Hyrtl found stenosis of the umbilical vein consequent upon periphlebitis. *Theophilus Parvin.*

PRESBYOPIA (Pr), from πρέσβυς, old, and ὤψ, eye, is "the condition in which, as the result of the increase of years, the range of accommodation is diminished, and the vision of near objects interfered with."[1] The range of accommodation diminishes year by year, from about 15 dioptrics ($1/2\frac{2}{3}$), at the earliest age (ten years) at which accurate observations have been made, to about 1 dioptric ($\frac{1}{40}$), at the age of sixty-five or seventy; at forty it amounts to something less than 5 dioptrics ($\frac{1}{8}$), and at forty-five to about 3.3 dioptrics ($\frac{1}{12}$).[2]

Of the 15 dioptrics of accommodation which the child

of ten years can bring into exercise, from two-thirds to three-fourths (10 to 11 dioptrics) may be lost without greatly incommoding an emmetrope in ordinary near vision. In emmetropia the distance (P_2) of the binocular near-point (p_2) is the reciprocal of the number of dioptrics of accommodation; hence, with a binocular range of accommodation of 5 dioptrics, $P_2 = \frac{1}{5}$ metre (20 centimetres = 8 inches), at which distance the smallest print in ordinary use is easily deciphered by eyes of average visual acuteness; when the range of accommodation is reduced to 4 dioptrics $P_2 = \frac{1}{4}$ metre (25 centimetres = 10 inches), at which distance ordinary newspaper print is still easily read; with the loss of another dioptric of accommodation (leaving but 3 dioptrics available), $P_2 = \frac{1}{3}$ metre (33.3 centimetres = 13.12 inches), and the reading of fine print becomes difficult, except under the favorable conditions of good illumination and normal acuteness of vision. These several values of P_2 correspond, in emmetropia, to ages ranging from about thirty-eight to about forty-seven years, and few emmetropes attain the latter age without seeking aid from convex glasses in reading or other fine work; the adoption of convex glasses by an emmetrope under forty, is generally determined either by the exacting nature of the work in which he habitually employs his eyes, or by the fact that his acuteness of vision is somewhat below the normal standard. When at the age of from fifty to fifty-five years the range of accommodation is reduced to 2 dioptrics, $P_2 = \frac{1}{2}$ metre (50 centimetres = 19.68 inches), and the book must be held at arm's length, at which distance only exceptionally large print can be read; but, even with this range of accommodation, a public speaker may be able to read fluently from a plainly written manuscript lying before him upon a reading-desk or table.

The diminution of the range of accommodation with advancing years is a strictly physiological change, and is directly related to the progressive increase in the hardness of the crystalline lens, in consequence of which it becomes less and less capable of undergoing the change in curvature required for the adjustment of the eye for near vision. As this hardening of the crystalline occurs in all eyes alike, irrespective of their refractive condition, as determined by the relation of the curvature of the refractive surfaces to the length of the axis of the eyeball, it would be scientifically correct to define presbyopia as the loss of accommodative power incident to advancing years. Immemorial usage has, however, associated the name with the special condition in which, as a result of increasing age, near vision becomes indistinct while distant vision remains either absolutely or relatively unimpaired. As thus defined, presbyopia is an incident in the life-history of all emmetropes and hypermetropes, and also of myopes whenever the myopia is of low grade—say, 3 dioptrics or less. In myopia of higher grades, say, of 4 dioptrics or more, the distance of the far-point remains within $\frac{1}{4}$ metre (25 centimetres = 10 inches) of the eyes, which is somewhat less than the usual reading distance for fine print; so that the characteristic disability of presbyopia, namely, the failure of vision for small near objects, is either never developed or only very late in life.* The apparent antagonism between myopia, in which only near objects are seen distinctly, and presbyopia, in which distant objects are seen clearly, while near objects appear confused, was very early recognized,[3] and, in the absence of any clear conception of the nature of the function of accommodation, presbyopia was, for more than two thousand years, regarded as the opposite condition to myopia. Hypermetropia, the true opposite of myopia, remained confounded with presbyopia until the middle of the present century, when the demonstration of the change in the form of the crystalline lens in accommodation by Cramer[4] and by Helmholtz,[5] and the masterly analysis of the phenomena of accommodation in its relation to the several anomalies of refraction, by Donders,[6] dispelled the cloud of obscurity in which the whole subject had been so long enveloped, and through which only momentary glimpses of the truth had been previously enjoyed by a few exceptionally acute observers.[7]

Premonitory signs of presbyopia may ordinarily be detected in emmetropes before the thirty-fifth year; exceptionally fine print, such as No. 1 of Jaeger's scale, is no longer read with the same perfect fluency as in youth, especially if the illumination is defective. Within the next five years the finer newspaper print loses something in sharpness of definition, and the finest needle-work becomes difficult, and perhaps deteriorates somewhat in quality. If the acuteness of vision (V—see Optometry) is normal, and the print is not too fine, relief from the consciously increasing effort in accommodation may be obtained by holding the book or work a little farther from the eyes; but if vision is subnormal, or if the print is bad or very fine, a stronger illumination may be demanded without increasing the reading distance. By the age of forty-five the disability has generally increased to the point that only fairly large print can be read with ease by ordinary artificial light, and a more powerful lamp is procured, or the book is held nearer to the light; about this time the probable need of help from glasses commonly suggests itself, and they are, perhaps, tried and adopted.

A hypermetrope habitually wearing neutralizing (convex) glasses, or a myope wearing neutralizing (concave) glasses, experiences the disabilities of presbyopic vision at about the same age, and in about the same degree, as the emmetrope; thus, between the ages of forty and forty-five, the hypermetrope discovers that his convex glasses are no longer quite sufficient in reading, and similarly, the myope discovers that his concave glasses have become something of a hinderance in near vision, although, in both cases, the neutralizing (convex or concave) glasses continue to serve perfectly for distant vision. A change to stronger convex glasses by the hypermetrope, or to weaker concave glasses (or, perhaps, the temporary removal of his glasses) by the myope is the remedy which now suggests itself, and which is, sooner or later, adopted. With the change of glasses reading again becomes easy, but with a corresponding falling off in the distinctness of distant vision; for this reason, an elderly ametrope ordinarily requires two pairs of glasses, the one pair (neutralizing) for distance, the other pair (stronger convex or weaker concave) for reading and other near work.

A hypermetrope, not wearing convex glasses, experiences the disabilities of presbyopia at an earlier age than the emmetrope, after having, perhaps, passed through a more or less protracted stage of suffering from asthenopia (see Asthenopia). In myopia, on the other hand, if of low grade, the reading-power with the unaided eyes is retained to a more advanced age than in emmetropia; in the higher grades of myopia the reading-power is retained indefinitely.

As a result of the very gradual increase in the resistance which must be overcome in order to effect such degree of accommodative adjustment as is still possible in presbyopia, the relation of the accommodation to the convergence undergoes an important change, the binocular accommodation (A_2) associated with convergence for the habitual reading distance of from thirty to thirty-five centimetres (12 to 14 inches) becoming at length nearly equal to the absolute accommodation (A); in other words, the binocular near-point (p_2) comes to coincide very nearly with the absolute near-point (p). With the use of convex glasses in near work, the distance (P_2) of the binocular near-point (p_2) undergoes a rapid increase, so that such reading-power as may have been retained up to the time of the adoption of the glasses is speedily lost, and reading without glasses becomes inpossible. Hence the common experience of presbyopes, that having once formed the habit of using convex glasses, their continued use has become imperative, and this whether the glasses have been adopted somewhat prematurely, or only after the need of them has become urgent. The too early use of convex glasses is, therefore, to be deprecated, as entailing upon the wearer all the disabilities of presbyopia several years, perhaps, before the normal age; on the other hand,

* That is, in connection with the moderate falling off of the refraction which occurs late in life, see p. 24.

as there is a definite limit to the absolute range of accommodation at any given age, the use of convex glasses cannot, as a rule, be deferred by an emmetrope much beyond forty-five, unless he be content to forego the use of the eyes in reading ordinary print, or in other fine work.

The total disuse of the accommodation for a considerable period, especially if occasioned by protracted and exhausting illness, may lead to the premature development of presbyopic symptoms, which may then be interpreted as an indication for the immediate adoption of convex glasses. If glasses are used in such a case, they should be of the least power compatible with the use of the eyes under favorable conditions of illumination, and the patient should be encouraged in the hope that, as the accommodative power increases with use, the glasses may be laid aside. In cases of this kind it is often possible to bring the accommodation again into effective use by the instillation, once or twice daily for a few weeks, of a weak solution of pilocarpine, and thus to put off the use of glasses for perhaps several years.

In addition to the impairment of the accommodation, which is the essential characteristic of presbyopia, the refraction undergoes, in the course of time, a slight but positive diminution, so that ultimately an emmetrope becomes slightly hypermetropic (H *acquisita*—see Hypermetropia), a hypermetrope somewhat more hypermetropic, and a myope somewhat less myopic; a very low grade of myopia may thus give place to emmetropia, or may even pass through emmetropia to hypermetropia. A low grade of hypermetropia which, sooner or later, necessarily becomes absolute (H *absoluta*), is, in fact, the ultimate normal condition of all emmetropes, so that weak convex glasses come to be required for perfect vision at a distance; hypermetropes similarly require a moderate increase in the power of their convex glasses and myopes require a corresponding diminution in the power of their concave glasses. This falling off in the refraction is ordinarily scarcely to be detected at the age of forty-five; at sixty it may amount to perhaps 0.5 dioptric, at seventy or seventy-five to 1 dioptric, and at eighty to 2 dioptrics or more.[8]

The treatment of presbyopia is necessarily confined to the palliation of the actual disability, by the use of such convex glasses as may suffice to supplement the failing accommodation and also to correct any existing hypermetropia, whether original or acquired. A person originally emmetropic may, at the age of seventy, require convex glasses of as much as 5 dioptrics power ($\frac{1}{8}$), in order to read fairly good print at a distance of from ten to twelve inches; and if the acuteness of vision is somewhat below the normal, it may be necessary to use glasses of 6 or 7, or even 8 dioptrics ($\frac{1}{7}$ to $\frac{1}{5}$), in order to admit of reading at the shorter distance of from nine to seven inches. In the case of a person originally hypermetropic, the measure of the required glasses will be increased by a quantity equal to the grade of the hypermetropia; in myopia the measure of the glasses will be similarly diminished.

The glasses first given to a presbyopic emmetrope of from forty to forty-five years of age, should ordinarily not much exceed 1 dioptric (say $\frac{1}{40}$ or $\frac{1}{36}$), and, in many cases still weaker glasses (say $\frac{1}{60}$ or $\frac{1}{48}$) are quite sufficient, and may be more acceptable to the patient than stronger glasses. These glasses should be used for only such work as is performed with difficulty without glasses (reading fine print by artificial light, etc.), in order that the habit of using the accommodation may not be needlessly or prematurely abandoned,* and they should not be exchanged for stronger glasses so long as they continue to afford the needed assistance. Subsequent changes should always be made with reference to the glasses actually in use, adding perhaps 0.25 or at most 0.5 dioptric at each change, and it is generally advisable to retain the old glasses for a time, for reading in bright daylight, reserving the stronger glasses for more exacting work. It follows that a presbyope should always know the power of the glasses which he is using, in order that, in replacing a lost pair, he may not be reduced to the necessity of selecting new glasses at random, or after a hasty and inadequate trial, conducted, perhaps, by an "optician" whose knowledge is limited to the trick of selling his wares.

A presbyope using glasses suited to his condition, is able to use his eyes in near work freely and without fatigue; glasses of insufficient strength fall short of affording the full measure of relief, and glasses of excessive strength compel the holding of the book too near the face, thus imposing needless work upon the recti-interni muscles, and so possibly giving rise to muscular asthenopia * (see Asthenopia).

The clinical investigation of any case of presbyopia involves, first of all, the careful testing of the eyes for ametropia (hypermetropia, myopia, or astigmatism; see these titles; see also Optometry). As has been already explained, the measure of any hypermetropia that may be detected must be added to, and the measure of any myopia subtracted from, the value of the glasses ordinarily required by an emmetrope of corresponding age, in order to arrive at an approximation to the glasses to be given for reading. These tests are best conducted at a range of at least five metres (about sixteen feet), and only after the satisfactory determination of the state of the refraction, should a trial of reading-glasses, based upon this determination, be made. The final tests are made in reading fine print (such as Nos. 1 to 5 of Jaeger's test-types). If astigmatism is present, it should, as a rule, be accurately corrected by having one surface of each glass ground to the appropriate cylindrical curvature (see Astigmatism).

A rapid increase in the grade of presbyopia, necessitating frequent and considerable additions to the strength of the reading-glasses, should always be regarded as a suspicious symptom, indicating the possible development of glaucoma.

Repeated changes from weaker to stronger glasses, but with a shortening of the reading distance after each change, point to a falling off in the acuteness of vision, oftenest from failure in the perceptive power of the retina, or of the conductive power of the optic nerve.

A marked diminution in the apparent grade of presbyopia is occasionally observed rather late in life, and is due to the development of a myopic state of the refraction; this change, which is popularly known as "second sight," is ordinarily a symptom of incipient cataract.

John Green.

1 Donders: On the Anomalies of Accommodation and Refraction of the Eye, p. 210. The New Sydenham Society. London, 1864.
2 Donders: Op. cit., p. 207.
3 Aristotelian Treatise, προβλήματα, xxxi., 25; cf. Paulus Aegineta.
4 Cramer: Tydschrift der Maatsch. vor Geneeskunde, 1851.
5 Helmholtz: Monatsberichte der Akademie der Wissenschaften, Berlin, February, 1853.
6 Donders: Archiv für Ophthalmologie, vi., 1860. On the Anomalies of Accommodation and Refraction, 1864.
7 Vide Donders: Op. cit., p. 325, note.
8 Ibid., p. 208.
9 Scheffler: Die Theorie der Augenfehler und der Brille. Wien, 1868.

PRESCRIPTION-WRITING. A medical prescription is a written order to the pharmacist to take certain quantities of certain medicines, deal with them in certain pharmaceutical ways, "put up" the product in certain form for dispensing, and label the package with certain directions for use. Correctness in prescribing, therefore, relates to the three several matters of the *selection of the ingredients* or *composition* of the prescription, the *fixing of quantities* or *computation* of the prescription, and the

* The proposal to make use of weak convex glasses somewhat before the appearance of marked presbyopic symptoms, for the alleged purpose of preserving and strengthening the sight, is so irrational as to justify the suspicion that it may have originated in the interest of trade; the only apparent foundation for such a practice is the fact that in hypermetropia convex glasses are needed at an earlier age than in emmetropia.

* Inasmuch as presbyopia is essentially an affection of the accommodation, the proposal to give convex glasses in which the spherical surfaces are ground upon prisms, with bases turned toward the nose (Scheffler[9]) is irrational. Such glasses, by lessening the tension on the convergence, tend also to lessen the concomitant exercise of the accommodation, and so may help to make stronger glasses acceptable than would otherwise be the case; this implies, however, the needless disuse of the remaining accommodation, and the promotion of an abnormally rapid development of the presbyopia.

actual *writing of the order* in technical style, or *expression* of the prescription, These several topics will be considered seriatim, in the order named.

I. The Composing of a Prescription.—Assuming that a prescription is intended, as should always be the case, to fulfil a single therapeutic purpose only, then the first point that presents is whether, under the circumstances of the case, a *single* medicine of the appropriate kind should be prescribed, or a *team* of such medicines. As regards this point, no general rule can be laid down —the matter will depend partly upon the nature of the therapeutic indication, and partly upon the respective peculiarities of the individual drug and the individual case. Thus to provoke *emesis*, a single drug is commonly prescribed; to excite *diuresis*, a team; while for *purging* the medicine will be single, if it be castor- or croton-oil, but multiple, if the selection be from among the resinous cathartics. The advantage of a team of similar medicines in prescription may be, on the one hand, a more *effective*, or, on the other, a more *kindly* accomplishment of the specific purpose in view, or it may be both possibilities combined. Thus, by a wise association in prescription of allied drugs, a maximum of therapeutic effect is attainable with a minimum of by-derangement. Having fixed upon the active member, or team of members, of the prescription, the next point is whether the medicinal working of the same may not be made even more effective or more kindly than would otherwise be the case by the further addition to the prescription of some special substance. Such increase in both lines—effectiveness and kindliness—may result by a chemical action upon the drug, on the one hand, or by a medicinal impression upon the system of the subject, on the other. Thus, as an instance of the working of a chemical action, stands the fact that the efficacy and kindliness of operation of a dose of *salicylic acid* are both enhanced by the addition to the acid of a solution of a sodic carbonate, whereby the salicylic acid, which under its own form is both insoluble and irritant, becomes the more soluble, and at the same time far less harsh, body, sodic salicylate. As instances of an associated medicinal impression by an unrelated drug affecting the operation of the active member of a prescription, may be cited the rather mysterious enhancement of the diuretic action of digitalis by the associate action of calomel, and the neutralizing of the griping of the rougher cathartics by the associated antispasmodic action of the pungent volatile oils, or of neurotics, such as belladonna or hyoscyamus. In the category of additions to a prescription for the purpose of enhancing *kindliness* of operation, belong *flavoring* substances. For an agreeable, or, at least, a not offensive potion, is not merely *pleasanter* than an ill-tasting one to swallow, but is also, by the very reason of non-offensiveness, far less likely than a nauseous dose to destroy appetite or derange digestion. The art of prescribing pleasant mixtures is therefore one of genuine advantage to the patient, as well as to the prescriber! Agreeability of taste is, of course, far more important in the case of fluid than of solid mixtures, and is attained, in the case of fluids, in part by wisdom in the selection of the active member of the prescription, and in part by the addition to the prescription of *sugar*, or of *syrup*, or of preparations of the more pleasantly flavored *aromatics*. Lastly, in composing a prescription, comes the thought of a possibly necessary substance to give *volume*, or, in the case of a powder or pill, to give *form*, or, in the case of a fluid mixture, to serve as a diluent, or as a solvent. The character and relative proportion of such a member of a prescription will vary so greatly in different cases, that no general rule affecting the selection of vehicles can be formulated. Members of a prescription for the several purposes named, are commonly referred to as, respectively, the *basis*, the *adjuvant*, the *corrigent*, and the *excipient*, or *vehicle*, of the prescription. In the association of different substances in a prescription, no matter what the purpose of the several ingredients, regard must always be had for the mutual *chemical* relations of the things so brought into mutual contact, lest undesirable reactions take place in the compounding (see Incompatibility, Medicinal).

II. The Computing of Amounts in Prescriptions. —The first point in the matter of amounts in prescriptions is, in general, *not to order more of the medicine than present prognosis seems to call for*. Not unnaturally, the laity instinctively argue that the remedy should fit the case in *measure* as well as in *mode*, and hence, that an excess of medicine in the prescription is *prima facie* evidence of a deficiency of skill on the part of the prescriber. They, furthermore, naturally object to the *paying* for the superfluous. Apart from these considerations, there are also many and obvious objections to a course that leaves half-used parcels of medicine to accumulate in a house, at the risk of inappropriate application on subsequent occasions, at ignorant hands. Hence, in cases where an exact forecast of the amount of a medicine likely to be required is impossible, it is wiser to order no more than will surely be within bounds, letting the prescription be renewed if the amount prove too little. Assuming due regard to be paid to this principle, then the determination of amounts in a given prescription proceeds, by theory, thus: the amount of *basis* will be the product of the two factors, *quantity of dose* and *number of doses* required, and the several amounts of the other ingredients will be deduced from the amount of the basis, in accordance with the respective requirements of relative proportion. In putting this theory into practice, however, the important consideration has to be regarded, that quantities must be such as can be conveniently expressed in terms of the system of weight or of measure employed in the prescribing. This consideration determines, in general, the use of *round numbers*, and, in particular, of *such* round numbers as best conform to the relation between denominations in the particular system of weight or of measure followed in the prescription. For example, in general, no prescriber would fix a dose to be expressed by such a number as *one and one-tenth*, whether referring to grains or grammes, nor would he ever estimate upon an aggregate of such an awkward number of doses as *seven*, or *eleven*, or *nineteen*, or *twenty-three*. And, for example again, in particular, the prescriber by the *apothecaries'* system of weight or of measure, recognizing the generally *duodecimal* ratio of the denominations of these scales, instinctively proportions the numbers of his prescription on a *duodecimal* basis. His ratios, that is, are as one to some one of the numbers 2, 4, 6, 8, 12, 18, 24, 60, 120, 180, 240, 480. On the other hand, if the *metric* system be the system followed, the *decimal* basis of this system almost of necessity entails the use of decimal ratios in proportioning amounts in prescription. Quantities are in this case fixed upon that are to each other as one to some number of this series of numbers: 2, 5, 10, 20, 25, 50, 75, 100, 200, 250, 500, 1,000. This fundamental difference in the figures to be used in working by the metric, as compared with the apothecaries', system, is a point very commonly overlooked by novices, in this country, in the art of prescribing by metric denominations. Because already fixed in the duodecimal habit through previous practice with the apothecaries' system, such novices are apt to compute in *duodecimal* ratios quantities which they then set down in terms of *decimally* related denominations—a proceeding wherein theoretical stupidity begets, as it should, practical disaster. For, by this proceeding, as it is hardly necessary to point out, there is wholly missed the one point of advantage which the metric system has to offer, namely, ease of computation by *decimal ratios*. A medicine, then, whose dose in prescription by apothecaries' weight is taken at *one grain*, is—or should be—in prescribing by metric weight, taken at *five* centigrammes, and not at the *six* centigramme amount which the American metric prescriber, translating from terms of apothecaries' weight, so commonly figures by. As well might an original metrician—to coin a convenient word—who essays a prescription by the apothecaries' system, first fix his dose, by his old metric habit, at five centigrammes, and then, blindly insisting on exactly that quantum, despite its unsuitableness to the foreign system of weights, prescribe in grains on the absurd basis of a *seven-eighths grain* dose!

Such are the essential points of the theory of computing prescription-amounts, and having due regard to these points, the prescription of *solid* mixtures for make-up into pills, powders, troches, suppositories, etc., is easy enough; but in the prescription of *fluid* mixtures many additional considerations enter into relation, as follows: In the first place, although it is not essential, it is yet elegant, and hence customary, to have a prescribed mixture aggregate *just a bottleful* of some one of the sizes of the medicine-phials of the shops. Regard must therefore be had to the several sizes of such bottles. In the United States medicine-phials are made of capacities conforming to *apothecaries' measure*, which capacities are severally as follows: *one, two,* and *four fluidrachms*, and *one, two, four, six, eight,* and *twelve fluidounces*. This fact of the conformity of medicine-bottles to apothecaries' measure, makes, in this country, the prescribing of fluid mixtures readier by the apothecaries' than by the metric system. Phials for metric prescription should be of the natural metric capacities, severally, of *twenty-five, fifty, one hundred, two hundred,* etc., *cubic centimetres;* but in this country phials of such capacities are, at least, not common. A few years ago an order, by this writer, upon a dealer for a set of such bottles, if they were procurable in the city of New York, was returned with the report that there was nothing of the kind in the market.

The second special point affecting amounts in the case of fluid mixtures relates to the case of solids in solution, the point being the physical fact that, in dissolving, a solid of a given measure in its condition of dry powder *does not augment the volume of the solvent by the full amount of such measure*, but, on the contrary, increases such volume so little that, in the ordinarily comparatively weak solutions used as medicines, the increment can safely be disregarded in the estimation of amounts for prescription.

The third point relates to the system by which, in a given case of a fluid mixture for internal giving, the *individual doses are to be measured out*. This consideration does not obtain in the case of solids, since, in such case, doses are defined by a stated number of pills, powders, or troches—are, that is, already apportioned by the apothecary. But in the case of a fluid mixture, the medicine is necessarily dispensed in bulk (except when put up in capsules), and doses must be measured out by the administrator at the bedside. The point then presents itself of practical bearing, whether, in a given case, the dose is to be measured by a method of precision—by use of a graduated pipette, if the dose be quite small, or of a graduated vessel if of ordinary or large dimension—or whether the determination is to be by the conventional *drop* on the one hand, or *spoonful* on the other. If a graduate is to be used, then the point now in question does not present itself; but if the *drop* or the *spoonful* is to measure the dose, then the consideration arises, in the apportioning of amounts in prescription, of the respective actual *dimensions* of these variable measures, under the conditions obtaining in the individual case. As regards the *drop*, it must be remembered that this measure varies in dimension, not only according to the viscosity and specific gravity of the fluid dropped, but also according to the *shape, extent,* and *character* of the surface from which the drop delivers itself, and even, furthermore, in the case of drops delivered from a phial, according to the *degree of fulness of the bottle* on the occasion of the dropping. A bottle with a flanged mouth, such as the ordinary medicine-phial, yields, with the same fluid, a comparatively large drop when full or nearly so at the dropping, and a comparatively small one when at least half empty, the difference in the respective drop-dimensions in the two instances being even as considerable as that between the numbers five and three. The reason for this difference in size of drops is that, from a full bottle, the contents begin to run out when the bottle is but slightly tipped, and so, because of the position of the free edge of the lip, the nascent drop creeps into the re-entrant angle formed by the under surface of the lip and the side of the neck, and there has a chance to grow to a comparatively goodly size before gravity determines the fall. On the other hand, a phial half empty must be tipped to the horizontal before the contents can run out, in which position the narrow rim of the lip points directly downward, and so presents but a small surface-area for the fluid to cling to. Under these circumstances the fall will necessarily be in comparatively small drops. As regards the *spoonful*, it must be remembered that this measure, like the drop, is subject to variation, so that, in the case of prescriptions containing powerful medicines, amounts should be calculated on the basis of the *maximum capacity of the measure.* Whatever, then, may be the variation from the calculated dose in actual mensuration, will be on the safe side of a *shortage* instead of a possible *excess* of amount. Now a given spoon will naturally hold more of a *viscid* than of a *thin* fluid, and, in practical mensuration, will more readily hold its full complement when the fluid is poured *into* it, as from a bottle, than when the spoon is made to dip up the fluid from an open vessel. Hence, in the case of a *syrupy* mixture, with the dose to be taken *direct from the phial*, the conditions obtain where the spoonful will be at its maximum; while, on the other hand, in the instance of a thin watery dilution standing in a tumbler, with the dose to be dipped up by means of the spoon, the measure, although the same in name, may be very different indeed in fact. Another point, which should be thoroughly understood, relates to the size of the average spoon of to-day as compared with the spoon of the same denomination of two generations ago. Coming down from our ancestors is the estimate of the *tablespoonful* as the measure of half a fluidounce, or sixteen cubic centimetres, and of the *teaspoonful* as that of a fluidrachm, or four cubic centimetres. These alleged equivalences, true of the average of spoonfuls of former days, are still handed down as present truth from teacher to student, and so come to be almost universally applied in prescription calculations. If, however, the reader will take from any chance pantry a sample of the average commoner kind of teaspoon, such as is generally relegated for service in the nursery, and will provide for himself an accurate graduate and a phial of water, he can learn for himself, in two minutes, the fact that the teaspoonful will run much nearer *six* to the fluidounce than the traditional *eight*—will equal the quantity of *five* rather than of *four* cubic centimetres. And, by the same token, the average tablespoonful of our own present spoons is of the dimension of *three* rather than of *four* to the two-fluidounce measure—of *twenty* rather than of *sixteen* cubic centimetres. And, indeed, in the case of thick fluids, such as strongly syrupy mixtures, or a fixed oil like castor-oil, where also the fluid is poured into the spoon, the spoonful will considerably exceed even these larger estimates. In view of these facts, this writer, in his teaching, has always advised for prescription-purposes the estimate of the equivalence of the teaspoonful as at five cubic centimetres, or at the rate of six to the fluidounce; and of the tablespoonful at twenty cubic centimetres, or at the rate of three to two fluidounces—six to four fluidounces.

By basing calculations on such assumed equivalences, any error in actual mensuration will be, as it should be, in the direction of a measure smaller rather than greater than intended. Furthermore, it is a happy fact that these equivalences give numerical relations far handier for purposes of calculation than the older estimates. In the case of the metric values, it goes without saying that for computation in decimal denominations, the numbers *five* and *twenty* are much more convenient for expressions of respective unit-quantities than the numbers *four* and *sixteen.* And in the apothecaries' system the proportion of six to the fluidounce permits of a greater number of easily calculated combinations than the time-honored eight to the same measure, as is shown in the tables below.

A fourth consideration affecting the estimation of amounts in the prescription of fluid mixtures, obtains in the prescribing of a solid to be borne in solution in an inert fluid menstruum, the point being the matter of the proper proportion between solid and solvent. Of course, in the first place, the proportion must be compatible with the solubility, in the selected menstruum, of the given solid; and, also of course, in the second place, if the

dose is to be extemporaneously diluted for the taking, the concentration of the prescribed solution may be to any degree so compatible with solubility. If, however, as so often is the case, the prescription proposes a solution fit for direct administration without further dilution, then the consideration of *taste* enters into relation. An over-strong solution will be rough to the taste, and may also be irritant or even corrosive to the alimentary mucous membranes; while, on the other hand, if the solution be inordinately weak, the volume required for the carrying of a proper dose of the dissolved basis may be inconveniently large. Of course, in this matter the individual peculiarities of the constituents of a given prescription will require individual consideration; but, in a general way, the truth obtains that the *teaspoonful* is best made the carrier of not more than—in convenient round numbers of the respective systems of weight—*twenty-five centigrammes*, or *five grains*; and, similarly, the *tablespoonful* of not more than, respectively, *one gramme*, or *twenty grains*, of a solid in solution. In the case of fairly bland substances, whose solubilities will at the same time permit, twice these quantities may be permissible; but such proportion should not be exceeded.

From this presentation of points affecting the prescription of fluid mixtures, it appears that, in cases where it is expected that the whole bottleful is to be used, the estimate of amounts must harmonize a trio of conditions as follows: 1, The total must be just a bottleful; 2, it must aggregate *about* the number of doses therapeutically indicated; and, 3, at the same time the amount of the active basis, while being such as to yield the proper strength of solution, must also be such as to admit of ready expression in terms of the system of weight or measure employed in the writing. In the use of the metric system this triple harmonization presents no difficulties, for the simple reason that since *any* amount is equally easy of expression by this system, it is only necessary to harmonize the first two considerations, letting the amount of active basis required foot up to what it will. Thus, for instance, let it be supposed that an indication seems to call for a medication three times a day for a few days; then all it is necessary to remember is that, if the active basis be one of small dose such that a teaspoonful is the more convenient carrier, a *fifty cubic centimetre* aggregate will fulfil the conditions of an even bottleful on the one hand, and about the requisite number of doses upon the other (ten teaspoonfuls, reckoning the teaspoonful at five cubic centimetres). Then the individual dose of basis may be taken unconditionally by the therapeutic indication—it may be fixed at one, two, three, four, five, six, seven, eight, nine, ten, or any odd number of centigrammes, and the expression of the aggregate will be equally easy, such aggregate being simply ten times the quantity for the individual dose, respectively as follows: 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 1.00 Gm., etc. Similarly, if the case be one where a *tablespoonful* will be the more convenient measure for the dose, then a *two hundred* cubic centimetre volume will again yield ten doses (about the number indicated) of the selected dimension, and once more the individual dose of basis may be what it please, and the aggregate will be equally easy of expression. When, however, the *apothecaries'* system is followed in the prescription, at once a complication arises, for the reason that in apothecaries' weight all amounts are *not* equally easy of expression—some, indeed, being so awkward to express as to be practically unavailable. Thus, for instance, although by this system, as already pointed out, ratios are naturally taken in duodecimals, yet such a natural duodecimal multiple as *seventy-two*, representing grains, is a monstrosity for expression. In computing, therefore, by apothecaries' weight and measure, the prescriber is bound by the clumsiness of the denomination-ratios of the system, and so, for cases where the total basis exceeds a drachm, finds available for the fulfilment of the tripartite conditioning set forth above, a certain set of combinations only. These combinations the young prescriber must learn by rote. They are easily enough figured out for one's self; but for convenience of reference there are set forth, in tabular form below, the combinations convenient when the individual dose of basis is to be one or other of the several amounts, *five*, *ten*, *fifteen*, or *twenty* grains. If the individual dose of basis be *less* than a grain or two, then the total amount of basis required, being but a *moderate number of grains*, is easy enough of expression, and the difficulty now under consideration does not obtain.

TABLE OF CONVENIENT COMBINATIONS FOR THE PRESCRIPTION OF FLUID MIXTURES BY APOTHECARIES' MEASURE AND WEIGHT.

1. *Dose to be borne in an average teaspoonful, reckoning six teaspoonfuls to the fluidounce.*

Capacity of phial in fluidounces.	Number of teaspoonfuls contained.	Amount of basis to be prescribed in order to yield to the teaspoonful the several doses of			
		Five grains.	Ten grains.	Fifteen grains.	Twenty grains.
½	3	gr. xv.	ʒ ss.	....	ʒ j.
1	6	ʒ ss.	ʒ j.	ʒ iss.	ʒ ij.
2	12	ʒ j.	ʒ ij.	ʒ iij.	℥ ss.
4	24	ʒ ij.	℥ ss.	ʒ vj.	℥ j.
6	36	ʒ iij.	ʒ vj.	ʒ ix.	℥ iss.
8	48	℥ ss.	℥ j.	℥ iss.	℥ ij.
12	72	ʒ vj.	℥ iss.	...	℥ iij.

2. *Dose to be borne in an average tablespoonful, reckoning one and a half tablespoonful to the fluidounce.*

Capacity of phial in fluidounces.	Number of tablespoonfuls contained.	Amount of basis to be prescribed in order to yield to the tablespoonful the several doses of			
		Five grains.	Ten grains.	Fifteen grains.	Twenty grains.
2	3	gr. xv.	ʒ ss.	....	ʒ j.
4	[illegible]	ʒ ss.	ʒ j.	ʒ iss.	ʒ ij.
6	9	....	ʒ iss.		ʒ iij.
8	12	ʒ j.	ʒ ij.	ʒ iij.	℥ ss.
12	18	ʒ iss.	ʒ iij.	....	ʒ vj.

3. *Dose to be borne in a measured fluidrachm.*

Capacity of phial in fluidounces.	Number of fluidrachms contained.	Amount of basis to be prescribed in order to yield to the fluidrachm the several doses of			
		Five grains.	Ten grains.	Fifteen grains.	Twenty grains.
½	4	℈ j.	℈ ij.	ʒ j.	℈ iv.
1	[illegible]	℈ ij.	℈ iv.	ʒ ij.	℈ viij.
2	16	℈ iv.	℈ viij.	℥ ss.	℈ xvj.
4	32	℈ viij.	℈ xvj.	℥ j.	...
6	48	℥ ss.	℥ j.	℥ iss.	℥ ij.
8	64	℈ xvj.	....	℥ ij.	....
12	96	℥ j.	℥ ij.	℥ iij.	℥ iv.

4. *Dose to be borne in a measured half fluidounce.*

Capacity of phial in fluidounces.	Number of half fluidounces contained.	Amount of basis to be prescribed in order to yield to the half fluidounce the several doses of			
		Five grains.	Ten grains.	Fifteen grains.	Twenty grains.
1	2	gr. x.	℈ j.	ʒ ss.	℈ ij.
[illegible]	4	℈ j.	℈ ij.	ʒ j.	℈ iv.
4	[illegible]	℈ ij.	℈ iv.	ʒ ij.	℈ viij.
6	12	ʒ j.	ʒ ij.	ʒ iij.	℥ ss.
[illegible]	16	℈ iv.	℈ viij.	℥ ss.	℈ xvj.
12	24	ʒ ij.	℥ ss.	ʒ vj.	℥ j.

III. THE EXPRESSING OF A PRESCRIPTION.—A prescription is an order, *dated* and *signed*, to the pharmacist to take certain quantities of certain several substances; to perform upon them certain pharmaceutical operations; to label the package with certain directions concerning use, and to address it with the name of the patient. Upon this order the author may also have occasion to set down certain injunctions, such as "not to be renewed," or, "not to be shown to the patient," etc. In *form*, pre-

scriptions are commonly written after the following paradigm :

[*Not renewable without authority.*]

For Mr. A. B.

Take

Of substance *A*, quantity *x*.
Of substance *B*, quantity *y*.
Of substance *C*, quantity *z*, [etc.]

Do so-and-so [with them]......................
Label [the package]..............................

[*Signed*] C. D., M.D.,
No. 1 Blank Street.

[Dated] November 22, 1886.

Instead of a written signature, a very common and a very good plan, followed by many practitioners, is to have prescription-blanks printed for their personal use, bearing the imprint of name, address, and office-hours. In such case the imprint is commonly at the head of the paper. In *language*, a prescription is commonly written in part in Latin, and in part in the vernacular. In the United States the use of the Latin is commonly confined to such portion of the prescription as has to do with directions to the pharmacist for the compounding and "putting up" of the medicine; but in many other countries the *directions for use* are also written in Latin. This latter foreign custom has nothing to commend itself, but, on the contrary, is intrinsically objectionable on the score of opening an unnecessary doorway for the entry of mistakes. For such directions must, of necessity, finally appear in the vernacular in the label upon the package which is to serve for the patient's guidance; so that, to write them in the prescription in Latin is to entail their translation back into the vernacular at the hands of the pharmacist for the purpose of transcription, all at the risk of mistakes. Far better is the American custom, whereby the prescriber can—and always *ought*—set down, in the vernacular, in *fullest necessary detail*, the directions for administration, which directions are then simply to be copied, *exactly as written*, in the labelling of the package. Another, and quite universal, custom is to express by *abbreviation* or by *symbol*, in the pharmaceutical portion of the prescription, what might be called *staple* words. Thus, in the foregoing paradigm, *take* is expressed by the symbol "℞," which, originally the astronomical sign "♃," of the planet Jupiter (symbolical of the prayer to the deity Jove which in ancient times headed prescriptions), now bears its present peculiar form in order to do duty also as the initial letter of the Latin word *recipe*, signifying *take thou*. Next, titles of denominations of weight or measure are expressed by the commonly employed symbols for such denominations, and numeral adjectives by the so-called *Roman* numerals in the use of the *apothecaries'* system of weight or measure; but by the ordinary *Arabic* numerals when the prescription is by *metric* weight or measure, as is practically a necessity for the expression of the related integral and decimal fractions by which metric quantities are signified. Next, the word *misce*, signifying *mix thou*—the most commonly occurring word expressing requirement of pharmaceutical manipulation, is expressed by its initial letter *M.*, and similarly, and lastly, the word *signa*, signifying *label thou*, by its initial letter *S.* Other commonly employed abbreviations are "āā" for *ana*, latinized Greek for the phrase *of each*; "no." for *numero*, signifying *to the number of*; "q. s." for *quantum sufficiat*, signifying *as much as may be necessary*, and "p. r. n." for *pro re natâ*, signifying *according to need*.

It thus appears that all of the prescription requiring full dress in Latin is comprised in the titles of substances prescribed, and in the directions for the compounding. And for the correct latinizing of such items a critical knowledge of the Latin language, though, of course, of great advantage, is yet not indispensable. For, so far as relates to the expression of *medicine-titles*, all that is necessary is to know how to set these titles in proper *case*, and, as concerns the expression of *pharmaceutical directions*, it is to be remembered that, in the great majority of instances, the directions for compounding requiring specification in prescription-writing, are simple and set, so that their Latin phrasing is easily compassed by the knowledge of a few arbitrary words and phrases. Indeed, for all but seldom occurring exceptional directions, the latinizing can be effected by the words and phrases in the following list, properly coupled with the Latin words signifying forms of medicines, presumably already learned.

List of Odd Words and Phrases of Common Occurrence in the Expression of Pharmaceutical Directions, in Prescriptions.—1. *Verbs*, in *imperative mood*; "object" to be in the *accusative* case (analogue of the English *objective*):

Ádde, add.	*Fíltra*, filter.
Cóla, strain.	*Mácera*, macerate.
Dívide, divide.	*Mísce*, mix.
Exténde, spread.	*Sólve*, dissolve.
Fac, make.	*Tére*, rub.

2. *Verbs*, in *subjunctive mood*, taking a *subject* or a *predicate*, *nominative*:

Búlliat, let [it] boil.
Fíat, let [*it*] be made [into].
Fíant, let [*them*] be made [into].

3. *Verbal adjective* (participle) to agree with its noun in gender, number, and case:

Dividéndus (masculine); *-a* (feminine); *-um* (neuter), to be divided.

4. *Prepositions:* noun following to be in the *accusative* case:

Ad, to; up to. *In*, into. *Súpra*, upon.

5. *Prepositions:* noun following to be in the *ablative* case:

Cum, with. *Pro*, for.

6. *Miscellaneous Words and Phrases:*

Ána, of each.	*Guttátim*, by drops.
Béne, well,	*Non*, not.
Bis, twice.	*Sémel*, once.
Déin or *deínde*, thereupon.	*Símul*, together.
Et, and.	*Státim*, at once.
Gradátim, gradually.	*Ter*, thrice.

In the instance of a pharmaceutical operation which cannot be expressed in Latin by the application of the foregoing vocabulary, the wise course, even for the Latin scholar, is to forego elegance and write the direction in the vernacular. Otherwise it might chance that the prescription overstep the pharmacist's capacity for translation, to the obvious defeat of the compounding.

As regards the rendering, in proper Latin case, of the titles of the ingredient substances of a prescription, the points are as follows: There are, in Latin, six cases in the declension of nouns and adjectives, but of these cases four only are concerned in the latinizing of medicine-titles. These four are, respectively, as follows: The *nominative* case, corresponding to the English nominative, is the case in which titular words stand in simple statement—by which, in short, names are learned. Thus we recognize prepared chalk by the Latin title *Creta præparata*, wherein the two words of the title are in the nominative case. Next, the *genitive* case corresponds to the English *objective* case after the preposition *of*, and is the case in which titular words most commonly stand in prescription-writing. For, in the first place, *compound* titles, even in simple statement, commonly afford an instance of the genitive, as in the case of the title *tincture of opium*. Here the phrase *of opium* is rendered in Latin by the word *opium* set in the genitive case. Then, in the second place, in prescribing, the order for the "taking" of a given ingredient is, in the enormous majority of instances, a direction for the taking of a specified *quantity of* the substance in question. A prescription for a phial of laudanum, that is, will read: "Take *of* tincture of opium one-half fluidounce." In such case the titular word of the preparation itself—in this instance the word *tincture*—will have to stand in the genitive, since now it, also, follows the preposition *of*. With the exception, therefore, of a few conditions when titular words stand, in prescription-expression, in the *accusative*, the rule is that all titular nouns and adjectives which, in simple statement of the title, stand in the *nominative*, require, in prescription-orders, to be set in the *genitive*.

The third Latin case that concerns the prescriber is

the *accusative*, the Latin analogue of the English *objective following a transitive verb*. Titular nouns and adjectives take the accusative under the two following circumstances: First, when the order is not the common one to take a certain specified measure or weight *of* the thing, but to take *the thing itself* in a conditioned entirety. A common instance of this circumstance is where yolk or white of egg is an ingredient of a prescription. Here by the condition of things it is easiest to measure quantity by the natural measure of the egg-substance itself. Hence, in prescribing yolk the order is commonly to *take the yolk of one egg*, or of two, or of three eggs, as the case may be; in which case the title-word *yolk*, standing as the direct object of the transitive verb *take*, requires to be put in the accusative. Another commonly occurring instance where the accusative must appear, is where the prescriber writes for a certain *number* of a ready-made medicinal *entity*, such as pills or troches, of standard composition, and hence of independent title. Thus, to prescribe the pharmacopœial *compound cathartic pill*, the simplest way is to order directly the desired *number* of the already made pills, which the pharmacist keeps in stock. Such prescription, therefore, reads: "Take compound cathartic pills to the number of" so many, and so the word for *pills*, with its dependent adjectives, appearing as the immediate object of the verb *take*, stands in the accusative. The second circumstance determining the setting in the accusative of titular nouns and adjectives occurs, in one form of writing, in cases where the prescription orders that a given substance be taken *up to the attainment of a certain total bulk or weight.* This form of order most commonly obtains in the prescription of fluid mixtures, where it is often convenient to order in specified quantities the necessary amounts, respectively, of basis or adjuvant; but, as regards the inert *vehicle*, to simply direct the compounder to "take" the vehicle substance until the whole mixture shall attain the measure of the desired bottleful. In such case the order for the vehicle may be phrased in either of two styles—in the one of which the titular words will appear as usual in the genitive, but, in the other, in the accusative. The phrase in the latter style is according to the model, *take so-and-so up to [the measure of] so much.* Here the title of the substance "taken" is the immediate object of the verb *take*, and therefore stands in the accusative; the phrase *up to the measure of* being expressed by the preposition *ad*. The other style of phrasing the order is after this model: *Take of so-and-so as much as may be necessary to attain the measure of so much.* Here the title of the medicine once more follows the preposition *of*, and hence appears in the genitive. In the rendering of the order in this style, the Latin phrase *quantum sufficiat ad* (commonly abbreviated to *q. s. ad*) is the translation of the English "as much as may be necessary to attain the measure of."

The fourth and last Latin case that concerns the prescriber is the *ablative*, a case corresponding to the English objective after certain prepositions. The prepositions governing the ablative that occur in prescription-writing are *cum*, "with," and *pro*, "for." The former of these occurs in a few titles, as for instance, *Hydrargyrum cum Cretâ*, mercury with chalk; *Emplastrum Picis cum Cantharide*, pitch plaster with cantharides; and the latter in the much-used phrase *pro re natâ*, "according to need." But as regards the ablative, the special point obtains that the circumstances of prescription-phrasing never require the rendering in the ablative of a title-word which in the title appears in a different case. The few instances of the ablative in medicine-titles are therefore fixed, and the ablatives so occurring are easily learned by rote.

The *expression* of case is, in Latin, effected by modification of the ending of the word itself which is to be declined, and in such modification, *adjectives* share as well as nouns. Different modifications are employed to signify case in the singular and plural number, respectively, and of such modifications there are, in ordinary, five distinct systems, constituting the five several *declensions* of nouns and adjectives, besides cases of irregular declension presented by certain pronouns and cardinal numerals. Of the five systematic declensions, one, the *fifth*, affords but a single example in prescription Latin, namely, the ablative *re* of the noun *res* in the oft-quoted phrase *pro re natâ.* Of the other four declensions, examples occur in prescription-writing, of the *nominative, genitive, accusative* and *ablative* cases, respectively, in the singular number, and of the *nominative, genitive,* and *accusative* in the plural. The following table shows the endings for the several cases so enumerated, so far as concerns nouns and adjectives embraced in the prescriber's vocabulary. Endings for nouns not in such vocabulary are purposely omitted, as are also the irregular declensions of pronouns. In the table the italicised letters *m., f.,* and *n.*, signify respectively, that the case-endings in the columns beneath are those of nouns or adjectives of the *masculine, feminine,* or *neuter* gender; for, as appears in the table, case-endings often differ, even in the same declension, according to the gender of the word. The endings of the first and second declensions, severally, which appear *in parenthesis*, are the endings of certain Greek nouns, adopted into Latin with something of the Greek form retained. The table also gives a list of words of foreign origin applied as drug-titles, which, following the Latin idiom in such case, make no change of ending to signify case—are, in short, *indeclinable.*

TABLE OF PARTS OF LATIN DECLENSIONS SO FAR AS EXEMPLIFIED BY WORDS USED IN PRESCRIPTION-WRITING.

1. *Regular Declensions of Nouns and Adjectives.*

	First Declension.	Second Declension.		Third Declension.		Fourth Declension.
	f.	*m.**	*n.*	*m. and f.*	*n.*	*m.*†
SINGULAR:						
Nominative..	-a (-e)	-us (-os)	-um (-on)	(various)	(various)	-us
Genitive......	-æ (-es)	-i		-is		-ûs
Accusative....	-am (-en)	-um (-on)		-em	(like nom.)	-um
Ablative......	-à	-o		-e		
PLURAL:						
Nominative...	-æ	-i	-a	-es	-a	-us
Genitive......	-arum	-orum		-um, -ium		-uum
Accusative....	-as	-os	-a	-es	-a	-us

(Fifth Declension exemplified only in ablative singular *re* in phrase *pro re natâ.*)

* Except *juniperus, prunus, sambucus,* and *ulmus*, feminine.

† Except *cornus* and *quercus*, feminine.

2. *Declension of Cardinal Numerals.*

	Unus, One.			*Duo*, Two.			*Tres*, Three.	
	m.	*f.*	*n.*	*m.*	*f.*	*n.*	*m. and f.*	*n.*
Nominative..	un-us	-a	-um	du-o	-æ	-o	tr -es	ia
Genitive		-ius		-orum	-arum	-orum	-ium	
Accusative...	-um	-am	-um	-os	-as	-o	-es	-ia

All other cardinal numerals are indeclinable.

INDECLINABLE DRUG-TITLES—*all neuter.*

Amyl,	Coca,	Kino,
Azederach,	Curare,	Matico,
Buchu,	Elixir,	Sago,
Cajuputi,	Jaborandi,	Sassafras,
Catechu,	Kamala,	Sumbul.

As appears at a glance from the foregoing table, in the case of any noun or adjective belonging to either of the three declensions numbered as *first, second,* and *fourth*, respectively, if the *nominative* be given, any other case can be at once formed by substituting the proper case-ending for that of the nominative. In words of the *third* declension, however, this possibility in very many cases does not obtain. For in this declension the *nominative* often stands apart from the other cases in the way of having the very root, or "stem," of the word curtailed or modified in its construction. Thus, the stem *anthemid-*, giving genitive *anthemidis*, accusative *anthemidem*, and ablative *anthemide*, gives nominative *anthemis*—a word in which the full stem does not appear. Similarly, the root *flor-*, giving genitive *floris*, etc., gives nominative *flos;* and root *rho-*, giving genitive *rhois*, offers the much modified nominative form *rhus.* Hence, for the proper

rendering in oblique case of nouns or adjectives of the *third* declension, it becomes necessary to learn arbitrarily the form of some one of the oblique cases—most conveniently the genitive—as well as that of the nominative.

A special point concerned in the expression of case obtains in the case of *adjectives*, to the effect that very many of these words form their case-endings after different ones of the declension-models, according to the *gender* of the noun to which the adjective is attached. In compound drug-titles, therefore, which include an adjective, the gender of the noun modified by the adjective becomes necessary to know for the *intelligent*, proper rendering of the adjective's case-ending. Of course, such knowledge is not essential, since the title, adjective and all, can be learned by rote, and then, remembering the nominative form of the adjective, the necessary change to genitive or accusative, to suit the requirement of the prescription-phrase, can be done by rule. But it saves a vast amount of unnecessary memorizing to understand the system, so far as system goes, by which genders of Latin nouns are determined. Reverting, then, to the above declension-table, it appears that all prescription-occurring nouns of the *first* declension are *feminine* in gender; all those of the *second* declension ending in *-um*, or *-on*, are neuter, and, with a few exceptions, all of the *second* declension ending in *-us*, or *-os*, and all of the *fourth* declension ending in *-us*, are *masculine*. The exceptions in the two latter instances are nouns in *-us*, representing ancient Latin *tree-names*, which, because of the ancient Latin conception of an inherent feminity in trees as things, take the feminine gender in spite of their etymologically masculine nominative ending. In the *third* declension all genders appear, and, although in nouns of certain nominative-endings the ending carries with it the gender, yet in the case of many other nouns this is not so, and genders must be learned arbitrarily. Happily, however, the number of nouns of the third declension, among drug-titles, which bear an associated adjective, are quite few.

From the above analysis it is evident that, in the case of a given *noun* in the nominative, the rendering of the same in an oblique case can proceed by rule according to the foregoing declension-table, if only the declension of the noun be known; with the further item, in the instance of a noun of the *third* declension, that some one oblique case, as well as the nominative, be known, for the affording of the full stem of the word. Similarly, the proper case-dress of any given *adjective* can be fixed if the scheme of declension of the adjective itself be known, on the one hand, and, on the other, the gender of the noun to which the adjective is to be affixed—adjectives requiring to agree with their respective nouns in gender, number, and case. This requisite information concerning nouns and adjectives of prescription-use is afforded in the two following tables—the one giving a key to the declensions of nouns, with genders, and also, in the case of nouns of the third declension, genitive endings—and the other showing the schemes of declension of adjectives.

TABLE SHOWING DECLENSION AND GENDER OF NOUNS OCCURRING IN TITLES OF U. S. PHARMACOPŒIAL MEDICINES AND IN COMMON PRESCRIPTION-TERMS.

Nominative singular ending in **-a**:

All First Declension and Feminine, except (of Greek origin) *the following* in *-ma*:

Physosti′gma (physostig′matis), 3*d*, *n*.	E′nema (ene′matis), 3*d*, *n*.
[Aspidospe′rma (aspidospe′rmatis), 3*d*, *n*.]	Catapla′sma (catapla′smatis), 3*d*, n.
	Gargari′sma (gargari′smatis), 3*d*, *n*.

Nominative Singular ending in **-e**:

All First Declension, Feminine (Greek nouns).

[N.B.—Nouns in *-e* of Third Declension do not occur in prescription-writing.]

Nominative Singular ending in **-us**:

All Second Declension, Masculine, except—

Juni′perus, 2*d*, *f*.	Fru′ctus, 4*th*, *m*.
Pru′nus, "	Spi′ritus, "
Sambu′cus, "	Co′rnus, 4*th*, *f*.
U′lmus, "	Que′rcus, "
Rhus (rho′is), 3*d*, *f*. ("rhus glabra").	

Nominative Singular ending in **-os**:

Comprise only the following—

Prinos, 2*d*, *m*.	Bos (bo′vis), 3*d*, *m*. or *f*.
Flos (flo′ris), 3*d*, *m*.	

Nominative Singular ending in **-um**:

All Second Declension, Neuter.

Nominative Singular ending in **-on**:

Comprise only the following—

Erythro′xylon, 2*d*, *n*.	Eri′geron (erigero′ntis), 3*d*, *n*.
Hæmato′xylon, "	Li′mon (limo′nis), 3*d*, *m*.
Toxicode′ndron, "	

Nouns of all other endings are of Third Declension, and are as follows:

Ending in **-c**:

Lac (la′ctis), *n*.

Ending in **-l**:

(*-al*)	(*-ol*)
Chlo′ral (chlora′lis),	A′lcohol (alcoho′lis), *n*.
(*-el*)	Thy′mol (thymo′lis), *n*.
Fel (fe′llis), *n*.	[*N.B.—Some authorities regard these nouns in -ol as indeclinable.*]
Mel (me′llis), *n*.	

Ending in **-en**:

Alu′men (alu′minis), *n*.	Se′men (se′minis), *n*.

Ending in **-o**:

(*-io*)	(*-ago*)
Confe′ctio (confectio′nis), *f*.	Mucila′go (mucila′ginis), *f*.
Emu′lsio (emulsio′nis), *f*.	Ustila′go (ustila′ginis), *f*.
Lo′tio (lotio′nis), *f*.	(*-bo* and *-po*)
Po′rtio (portio′nis), *f*.	Ca′rbo (carbo′nis), *m*.
Tritura′tio (trituratio′nis), *f*.	Pe′po (pepo′nis), *m*.
	Sa′po (sapo′nis), *m*.

Ending in **-r**:

(*-er*)	(*-or*)
Æ′ther (æ′theris), *m*.	Li′quor (li′quoris), *m*.
Pi′per (pi′peris), *n*.	(*-ur*)
Zi′ngiber (zingi′beris), *n*.	Su′lphur (su′lphuris), *n*.

Ending in **-s**:

(*-as*, genitive *-atis*)	(*-is*, genitive *-eris*)
Ace′tas (aceta′tis), *m*.	Pu′lvis (pu′lveris), *m*.
[*and all salt-names in -as.*]	(*-is*, genitive *-is*)
(*-as*, genitive *-adis*)	Ca′nnabis (ca′nnabis), *f*.
Ascle′pias (asclepi′adis), *f*.	Digita′lis (digita′lis), *f*.
(*-is*, genitive *-itis*)	Hydra′stis (hydra′stis), *f*.
A′rsenis (arseni′tis), *m*.	Sina′pis (sina′pis), *f*.
[*and all salt-names in -is.*]	(*-os*, *see ante.*)
(*-is*, genitive *-idis*)	(*-us*, *see ante.*)
A′nthemis (anthe′midis), *f*.	(*-ns*)
Ca′ntharis (cantha′ridis), *f*.	Ju′glans (jugla′ndis), *f*.
Colocy′nthis (colocy′nthidis), *f*.	(*-ps*)
Hamame′lis (hamame′lidis), *f*.	A′deps (a′dipis), *m*.
I′ris (i′ridis), *f*.	(*-rs*)
Ma′cis (ma′cidis), *f*.	Pars (pa′rtis), *f*.

Ending in **-x**:

(*-ax*)	(*-ix*)
Bo′rax (bora′cis), *m*.	Pix (pi′cis), *f*.
Sty′rax (styra′cis), *m*.	Ra′dix (radi′cis), *f*.
(*-ex*)	Sa′lix (sa′licis), *f*.
Co′rtex (co′rticis), *m*. and *f*.	(*-ux*)
Ru′mex (ru′micis), *f*.	Nux (nu′cis), *f*.
	(*-lx*)
	Calx (ca′lcis), *f*.

TABLE SHOWING SCHEMES OF DECLENSION AND GENDER OF ADJECTIVES OCCURRING IN U. S. PHARMACOPŒIAL MEDICINAL TITLES AND IN PRESCRIPTION-PHRASES.

SCHEME I.—*Second and First Declensions Combined.*

Masculine.	*Feminine.*	*Neuter.*
-us [2d dec.]	*-a* [1st dec.]	*-um* (*-on*) [2d dec.]

SCHEME II.—*Third Declension.*

Masculine and Feminine.	*Neuter.*
-is (genitive *-is*).	*-e* (genitive *-is*).

SCHEME III.—*Third Declension.*

Masculine and Feminine.	*Neuter.*
-ior (genitive *-ioris*).	*-ius* (genitive *-ioris*).

SCHEME IV.—*Third Declension.*

All Genders.

-ens (genitive singular *-entis*); (genitive plural *-entium*).
-or (genitive *-oris*).

In commentary upon the declension-schemes of adjectives set forth in the foregoing table, it may be stated that Scheme I. embraces by far the greater number of adjectives. In this scheme the neuter ending *-on*, borrowed from the Greek like the same ending among nouns of the second declension, finds among drug-titles but a single example, *diachylon*. Scheme II. embraces a few adjec-

tives only among those occurring in medicine-titles, and affords an example of the nominative-ending *-e* of the third declension, which does not occur among *nouns* of pharmacopœial titles. Scheme III. is a special scheme for the declension of the comparative of adjectives, and affords but a single example from among the adjectives of medicine-titles, namely, the adjective *fortior, fortius,* "stronger." Of Scheme IV. pharmacopœial adjectives give but two examples in *-ens*, namely, *effervescens* and *recens*, and but one in *-or*, namely, *tricolor*. A survey of the *genders* marked on the table shows that in every case a distinctive gender, where there is such, can be told from the adjective nominative ending, with the exception that, among adjective nominatives in *-us*, one, *fortius*, is of the third declension neuter, and belonging to the third scheme, whereas all other adjectives of this nominative are of the second declension masculine, and belong to the first scheme. .

A final point, concerning the expression of a prescription, is that, having regard to the fact that a *slip of the pen* on the part of the writer, or a *slip of the understanding* on the part of the pharmacist-reader of a prescription, may convert what was meant as a missive of mercy into a death-warrant, it most solemnly behooves the prescriber to execute his task *deliberately, thoughtfully*, and, in chirography, *legibly, abjuring all dangerous cloak-of-ignorance abbreviation of medicine-titles ;* and, finally, to fail not of that trusty safeguard against error, a *review of the paper* after the writing. *Edward Curtis.*

PRIAPISM. The term priapism is usually understood to signify an unnaturally prolonged erection. The erection may be imperfect, or may even exceed the normal state, and is usually unaccompanied by sexual desire. It can hardly be considered as a distinct disease, but is probably always symptomatic of some abnormal local condition, or of some nervous derangement. A few cases have been reported in which it has followed violent or excessive coitus. A case was reported by Mr. Callaway[1] in 1824. The man was forty-four years of age, and while intoxicated had connection. Priapism continued for sixteen days, when Mr. Callaway "made an incision into the left crus penis below the scrotum, and a large quantity of dark grumous blood with small coagula escaped," and in a few days the man returned to work. Mr. Luke[2] reported a case in which priapism came on after repeated connection, and lasted for about four months. It occurs in connection with inflammations, new-growths, and traumatisms of the genito-urinary apparatus. Neumann[3] reports a case of carcinoma of the posterior and inferior wall of the bladder, with perforation of the bladder-wall and peritonitis, in which priapism was present for thirty-one days. The disease had invaded the vesiculæ seminales, the vas deferens, and the left ureter. It had compressed the vessels and caused inflammation of the corpora cavernosa.

In gonorrhœal inflammation of the vesiculæ erections are frequent and may amount to priapism.

In a case at the Boston City Hospital, rupture of the urethra and corpora cavernosa followed a fall upon the perineum. External urethrotomy was done, and an unsuccessful attempt made to unite the corpora by suture of the fibrous sheath. Partial priapism was present during the latter portion of the case, but finally disappeared.

Priapism occurs in a certain proportion of cases of acute poisoning from cantharides.

Priapism is a not uncommon symptom in acute myelitis. Generally the erection is incomplete, but it often persists for days with slight variations in degree. Injuries of the spine and cord are liable to be followed by continued or recurrent priapism, or by turgescence without rigidity. In eighty-two cases of fracture of the spine tabulated from the records of the Boston City Hospital, priapism occurred in eighteen.[4] It is most common in connection with crushing of the cervical portion, rarer with that of the dorsal, and, according to Erb,[5] never occurs with fracture from the third lumbar vertebra downward.

Priapism has been noted in some cases of tumor or other disease of the cerebellum and pons varolii, and is said to occur frequently in hydrophobia and tetanus.

The treatment must be directed mainly toward the condition of which priapism is but a symptom, but the patient's comfort may often be greatly increased by local applications of cold water or evaporating lotions, or by the local use of opium. Suppositories or cold rectal injections may give some relief. Internally the bromides are most likely to be of service. *Abner Post.*

[1] London Medical Repository, 1824, p. 286. [2] Lancet, July, 1845.
[3] Wien. Med. Jahrb., Heft ii., S. 143, 1883.
[4] Burrell: Transactions of the Mass. Medical Society, 1887.
[5] Ziemssen's Cyclopædia, xiii., p. 313.

PRO-AMNION. This convenient term was introduced by Ed. van Beneden to designate that part of the *area embryonalis* at the sides and in front of the head of the developing embryo, which remains without mesoderm for a considerable period, so that the ectoderm and entoderm are brought in the region of the pro-amnion into immediate contact. As found in one stage of the rabbit, it has already been figured in this work, vol. ii., p. 303. A later stage in the rabbit, as seen in longitudinal section, is figured by Kölliker in his "Grundriss d. Entwickelungsges.," 2 Aufl., p. 107. We find that it had been observed in the chick by Remak, His, and Kölliker. Strahl was the first to direct special attention to it. It has since been observed by various writers; van Beneden and Julin have described it in the rabbit, Heape in the mole, and recently its exact history has been admirably worked out in the chick by Ravn. The pro-amnion, then, has been observed in representatives of the classes Reptilia, Aves, and Mammalia; hence, we may conclude that it is common to all Amniota. It will be remembered that the mesoderm grows out in all directions from the blastopore, or hinder end of the primitive streak. In a chick of twenty-seven hours, the front edge of the mesoderm is a somewhat irregular transverse line, which crosses the germinal area about at the front border of the head. This line is well shown in His's drawings, loc. cit., Pl., xii., Fig. 14. As the mesoderm expands, it does not grow forward in the median line, but does grow forward at the sides of the *area pellucida* in front of the head of the embryo. A space is thus enclosed between the mesoderm on each side; this space later becomes the pro-amnion; it contains no mesoderm. Later on, the lateral portions of the mesoderm approach the median line again, some distance in front of the head, so that now the pro-amniotic area is completely surrounded by mesoderm. We see, as the next phase of development, the head amniotic fold arising in such a position that the pro-amnion is embraced between the arc of this fold and the head of the embryo; the pro-amnion, therefore, constitutes the floor of the pit formed by the upgrowth of the head amnion. In the chick the pro-amnion never acquires any considerable development, but gradually disappears by encroachments of the mesoderm upon all sides, as has been well described by Ravn, whose Fig. 3, loc. cit., Pl. xxi., will serve to give a clear general notion of the relation of the pro-amnion to the head, and to the true amnion in the chick. The disappearance of the pro-amnion in the chick involves some curious appearances in sections of embryos, which have not been understood hitherto, but which Ravn has correctly and fully elucidated, so far as I can judge.

In the rabbit, according to van Beneden and Julin, whose observations have been confirmed to a certain extent by Kölliker and Heape, the rôle of the pro-amnion is more considerable. The history of the pro-amnion, as given by van Beneden, may be followed easily by the aid of the accompanying diagrams (Fig. 3102), copied from van Beneden. In A, the pro-amnion, *pro.A*, is very small, and the allantois, *Al*, is just growing out. In B, the embryo, which for greater clearness has been shaded with stippling, has grown very much, and the anterior half of its body is bent down at a sharp angle into the yolk-sac. The embryo, however, remains separated from the cavity *Y*, of the yolk-sac, by the pro-amnion, which forms as it were a hood, *pro.A*, over the anterior

extremity of the embryo. The amnion proper is as yet developed only over the posterior end of the embryo. For the further history of the amnion see Amnion, vol. i. of this HANDBOOK. The pro-amnion, as can be seen in C and D, retains its importance as a fœtal covering for a considerable period, during which the amnion *am*, and allantois *Al*, are rapidly pursuing their development. After the stage shown in Fig. 3102, D, by the expansion of the cavity marked Coe', the amnion proper, *am*, encroaches more and more upon the pro-amnion, *pro.A*, until at last the embryo is entirely covered by the true amnion, and the pro-amnion is altogether lost. It is to be noted especially that the amnion develops principally over the posterior end of the embryo, and grows forward. To this fact reference will be made again directly.

We possess no observations at present, as to the existence of a pro-amnion in man, but from what we know of the early stages, we may conclude that it disappears quite soon after its origin; for we may assume that it occurs in man, since it has been demonstrated in all classes of amniota. This deduction renders it improbable to my mind that His's hypothesis of the formation of the human amnion is quite correct. We see, in fact, that in the amniota generally the principal growth of the amnion is from the allantois or allantois stock, when the allantois is rudimentary. This growth extends far forward, as in the rabbit—a point just mentioned. It is unlikely that man forms an exception to a rule of such wide application, in regard to an organ phylogenetically so ancient. It is a well-known rule that the older an organ in the evolutionary series, the less does its mode of development vary in any essential respect from species to species.

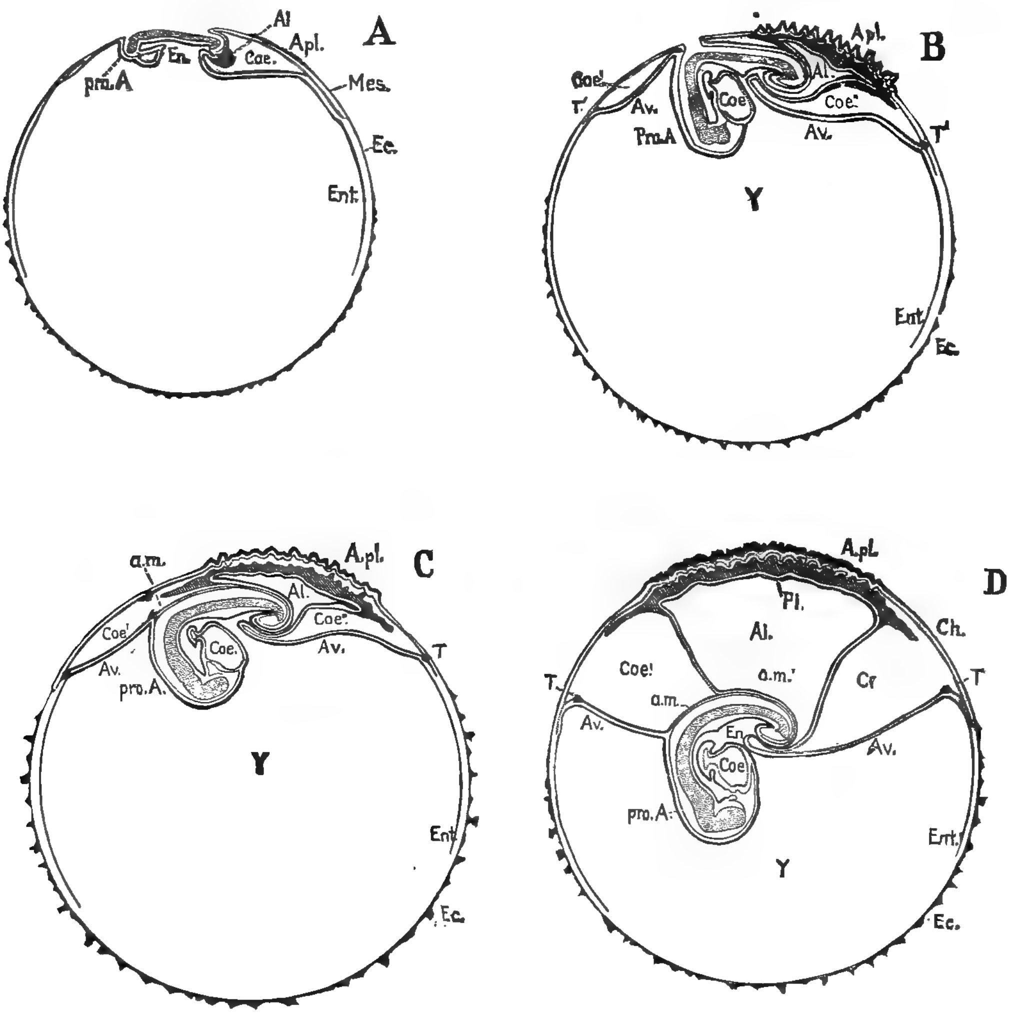

FIG. 3102.—Diagram of the Development of the Fœtal Adnexa in the Rabbit. (After van Beneden and Julin.) A, B, C, D, successive stages; *pro.A*, pro-amnion; *Av*, area vasculosa; *Coe*, cœlom; *Coe'*, *Coe''*, extra-embryonic portion of the cœlom; *En*, entodermic cavity of the embryo; *Ent*, extra-embryonic entoderm; *Ec*, ectoderm; *Mes*, mesoderm; *Apl*, area placentalis; *Al*, allantois; *T*, terminal sinus of the area vasculosa; *Y*, yolk-sac; *am*, amnion; *am'*, portion of the amnion united with the wall of the allantois; *Ch*, chorion.

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Charles Sedgwick Minot.

PROFESSIONAL NEUROSES. SYNONYMS.—Beschäftigungsneurosen, Professional Dyskinesiæ, Nevrose coordinatrice professionnelle, Anapeiratic Paralysis, Neural Disorders of Writers and Artisans.

DEFINITION.—Under the term professional neuroses is

included a class of spasmodic and co-ordinative disturbances mainly of functional origin, affecting the groups of muscles used in special kinds of muscular work.

While spasm and co-ordinative disturbance are the main and typical features, paresis, sensory disturbances, vaso-motor phenomena, and general nervous symptoms are also present.

FORMS.—Every class of work, or form of occupation, which calls for continual use of the same groups of muscles, furnishes examples of professional neuroses. The upper extremities are, however, naturally the parts chiefly affected. Those professions in which the smaller and more delicately adjusted muscular groups are brought into play, furnish the largest contingent. The list of names for the various forms of professional neuroses increases almost every year, and now includes: Writers' cramp; telegraphers' cramp; milkers' cramp; musicians' cramp, including pianists', violinists', flutists', and elocutionists' cramp; tailors' and seamstresses' cramp; blacksmiths' and carpenters' cramp, or hammer-cramp; dancers' cramp; photographers' cramp; watchmakers' cramp; cigarmakers' cramp; auctioneers' cramp; swimmers' cramp; sawyers' cramp.

HISTORY.—We hear nothing of any of these now numerous neuroses until about fifty years ago. Dr. Bern. Ramazini, who in 1746 wrote a work on the diseases of tradesmen, does not describe writers' cramp, although he speaks of the diseases which come from the sedentary life of the clerk. Ramazini says, that the causes of the "*morbi scriborum*" are "continua sessio, manus perpetua et eodem semper tenore motio, mentis attentio ne libros erroribus conspurcent." He cites only one case, that of paresis of the arm, which at all suggests writers' cramp. The disease, therefore, is undoubtedly a product of the present century. The idea that the Emperor Augustus had writers' cramp is based merely on a single sentence in Suetonius. The first to refer to the disease was Sir Charles Bell, who gives a brief account of a case of writers' cramp in his work on the nerves, published in 1830. A year later, a case was reported in Germany by Brück, and at about the same time one by Gierl. In the next four years, a number of German writers reported their observations of the disease. Cazenave, in 1835, was the first French writer upon the subject. In this country Weir Mitchell, Beard, Hammond, and Lewis have written specially upon it. In the past fifteen years the literature of professional neuroses has been continually enriched by the contributions of writers from various countries.

WRITERS' CRAMP (Syn.: Scriveners' palsy, mogographia, graphospasm, steel-pen palsy, chorea scriptorum).

Etiology.—As the disease is one of this century, it is most probable that the influences of our present civilization, by increasing the neuropathic constitution, furnish a larger material for writers' cramp. For a neuropathic history is present in many cases, and all writers, except Beard, agree that it is this class which is peculiarly liable to the disorder. A history of some family nervous affection, such as chorea, epilepsy, or insanity, is obtained in a minor proportion of cases. On the other hand, it is strikingly true that some victims of writers' cramp are strong and robust in every way. The explanation here is that such persons overwork themselves to a degree exceeding that which nervous and delicate persons can do. Those who write a beautiful hand are more liable to the affection than poor writers, for the reason, chiefly, that poor writers get no position in which they can overuse their writing-muscles. The introduction of steel pens (1820 to 1830) corresponds with the appearance of writers' cramp, and there is no doubt that the use of steel pens tends to favor this disease, owing doubtless to the roughness of the end. Besides this, steel pen-holders continually carry away heat from the fingers, thus tending to lower vitality, and are difficult to grasp firmly. Writers soon learn that wooden, rubber, or cork holders are safer. The introduction of stylographic pens, and especially of type-writers, may lessen the relative amount of writers' cramp, just as steel pens at one time increased it.

Americans ought, theoretically, to be very subject to writers' cramp. So far as I can learn, however, this is not the case, and, in my opinion, in New York City the disease is a somewhat rare one.

Men are much more subject to the disease than women, though the difference is not so great now as formerly, owing to the greater number of women employed in writing.

Among thirty-one cases of typical writers' cramp observed by Poore, all were men. Women are more liable to have impairment of the writing-arm from pains and paresis, without having the true professional dyskinesis.

The average age in cases collected and observed by Lewis was twenty-seven (26.96) years. Among 64 cases of Berger's, 24, or nearly one-half, occurred between the ages of twenty and thirty, 12 between thirty and forty, 16 between forty and fifty, 7 between fifty and sixty, 5 between sixty and seventy. On the other hand, Dr. J. Russell Reynolds's cases were all over thirty, and Dr. Hammond's cases all over forty. The cases which I have seen have all been a little over thirty. The disease occurs, therefore, very rarely before twenty, and most often at about the age of thirty.

The use of alcohol or tobacco in excess, onanism, and other sexual excesses, emotional disturbances, and worry, all predispose to the disease.

The exciting cause is the abuse of writing. In ordinary writing about four motions of flexure, extension, and lateral movement are made for each word. Calculating at the rate of five letters for a word, and twenty words per minute as the rate of writing, this would be two hundred and forty-five thousand muscular contractions in a working day of eight hours. When the speed is increased, and the hours of work lengthened, under the pressure of a desire to earn more or to complete a task, it is easy to understand how the nerve-cells may become exhausted, or refuse to work together. Persons who do copying or routine work are much more liable to the affection, but it is largely because they abuse their writing-powers. Persons who write as they compose—authors, literary men, clergymen—are not so subject to the trouble, because they necessarily rest more in their work. Brain-workers are, therefore, as a rule, exempt from writers' cramp.

Berger and Erlenmeyer seem to think that the "American method" of writing specially tends to produce cramp. The contrary is, I think, true. In the American, or free-hand, mode of writing, as taught in most of our schools, the wrist does not touch the paper, and the hand is just supported by the little finger, the motion being made largely by the whole arm.

Debilitating disease may lead to a development of writers' cramp. Weir Mitchell reports two cases occurring in patients who had albuminuria. The symptoms were relieved when the albuminuria was treated. Lead poisoning (Berger), exposure to cold and rheumatic influences, injuries of the arm, tight sleeves, ingrowing nails, the pressure of a sleeve-button on the ulnar nerve, have all been mentioned as exciting causes of the affection.

Pathological Anatomy.—Neuritis is undoubtedly present in some forms of writers' cramp, so-called. It is not present, however, so far as external tests go, in the typical neurosis. Nor are there any post-mortem observations throwing light on the anatomy of the disease.

Pathology.—We must believe, therefore, that it is a neurosis, having no appreciable anatomical basis.

The act of writing is a very complicated one, calling into play numerous sets of delicately innervated muscles.

These muscles are employed: 1, in pen-prehension; 2, in pen-movement; 3, in holding the arm and wrist tense.

1. The muscles employed in pen-prehension are the two outer lumbricales, two outer interossei, the adductor muscles of the thumb, the flexor longus pollicis; to some extent the deep and superficial, short and long flexors, and the extensors of the thumb. These are supplied mostly by the ulnar (interossei, adductor pollicis, inner heads of deep flexor of fingers, and inner head of short flexor of thumb). The rest of the muscles are supplied

by the median. (I cannot understand Poore's statement, that the muscles of pen-prehension are innervated by the median and musculo-spiral.) The spinal centre for these muscles, *i.e.*, for the intrinsic muscles of the hand, and for the extensors of the thumb and flexors of the fingers, is situated at the level of the eighth cervical and first dorsal nerves, and the cell-groups are probably the anterior and median.

2. In moving the pen, if the writing is done mainly by finger, and not by arm, movements, the muscles brought into play, according to Poore, are the flexor longus pollicis, extensor secundi internodii pollicis, flexor profundus digitorum, extensor communis digitorum, and to some extent the interossei. The musculo-spiral and ulnar nerves innervate these groups about equally. In moving the pen by the "American" or free-hand method, there is a very slight play of the above muscles, while most of the pen movement is done by the muscles of the upper arm and shoulder, viz., the teres major, pectorales, latissimus dorsi, biceps, and triceps.

The spinal centres for these muscles are distributed along the fifth, sixth, and seventh cervical segments of the cord. The cells are larger, and situated more superficially, in the anterior gray horns.

3. Besides these movements involved in pen-prehension, and in the letter-making, a certain amount of muscular tension is exercised in "poising" the forearm and hand and steadying the wrist. The biceps and triceps, the supinators and the flexors, and extensors of the hand are here brought into play.

From the foregoing it will be seen that the muscles of pen-prehension are most used in all but the free-hand style of writing, since the same groups have a double duty, that of clasping and of moving the instrument. That this prehension group is oftenest affected is shown by the following table, compiled by Poore from a study of thirty-two cases of undoubted writers' cramp. He found the muscles affected in the following proportions: Interossei (supplied by the ulnar), 18 times; extensors of thumb (supplied by musculo-spiral), 10 times; flexor brevis pollicis (supplied by median and ulnar), 7 times; abductor pollicis (supplied by median), 7 times; flexor longus pollicis (supplied by median), 4 times; adductor pollicis (supplied by ulnar), 3 times; opponens pollicis (supplied by median), 2 times; all the muscles of forearm, more or less, 2 times.

While writers' cramp is often complicated with some neurotic disturbance leading to associated symptoms of pain, paralysis, tenderness over nerves, vaso-motor disturbances, etc., there can be no doubt that the lesion in typical cases is central. Writing is an acquired automatic movement, and it must have as its anatomical basis a certain established arrangement of nerve-cell groups in the cervical part of the spinal cord. The nerve impulses generated in the cerebral cortex pass along the pyramidal tracts and set at work those ganglion groups which, in turn, innervate the muscles used in writing with motor impulses. These groups are themselves innervated also sensorially by the nerves of muscle-sense in movement. In writers' cramp the spinal groups of cells are more or less used up or exhausted, and the motor impulse which naturally would innervate them strikes cells which respond unequally, or it overflows to other cell-groups, and hence the spasmodic, irregular movements of the arm.

The cerebral centres in the cortex are closely connected with those in the cord, and may be said to form part of the writing-mechanism. It happens in some cases that this centre too is exhausted and discharges its impulses irregularly. In some cases, therefore, the cerebral, and in some the spinal, cell-groups are the more affected, and a diagnosis of the exact condition in each is approximately possible, and may be not without practical importance.

Writers' cramp is a disorder of efferent paths and stations. The muscular sense does not seem to be involved.

The pathology of writers' cramp is that of all the other forms of professional neuroses, and nothing need be said upon this point regarding them when they come to be considered.

Symptomatology.—Writers' cramp very rarely attacks a person suddenly. The patient first notices a certain amount of stiffness occurring at times in the fingers, or the pen is carried with some uncertainty, and jerky movements are made. He feels a sensation of fatigue in the hand and arm, and this may amount to an actual tired pain. The first symptoms may last for months or even years. The hand is rested as much as possible, new pens or pen-holders, and new modes of holding it, are tried. Often the patient, fearing the onset of the cramp, and as its result loss of employment, becomes anxious, worried, and mentally depressed. Sometimes the trouble is worse when beginning a daily task, and it gradually wears off in a few hours. At other times exactly the reverse is the case. When the disease has reached its highest stage, writing becomes almost or entirely impossible. The moment the pen is taken in the hand and an attempt at using it made, spasmodic contractions of some of the fingers, or even of the arm, occur, the pen flies in any direction, and it is impossible to control or co-ordinate the movements. In a well-marked case, with the history of which I am acquainted, the patient, when called upon to sign a check, was obliged to make an unintelligible scrawl, which was attested to by witnesses. The rule is that, although writing cannot be done, all other complex movements are performed as well as ever. Thus the sufferer from writers' cramp may be able to play the piano, or paint, or thread a needle, or use the hand in any complex movements. Telegraphers, however, who use to some extent the same muscles as in writing, and who also often have to do a great deal of writing, are liable to suffer from both writers' and telegraphers' cramp at the same time. No evidences of actual paralysis are present in the affected muscles, and there is rarely anæsthesia, but the arm aches and is sometimes tender. Sensations of numbness and prickling are present; in rare cases vaso-motor disturbances are observed; associated muscular movements of the other arm, or of the neck or face, sometimes occur. The hand may tremble on attempting to write, or fall almost paralyzed when the pen is taken.

The various symptoms occur with different degrees of prominence, so that the disease has been classed under the heads of, 1, the spastic; 2, the paralytic, and 3, the tremulous type. To this Dr. Lewis adds, types with 4, sensory, and with 5, vaso-motor symptoms.

Such a classification is convenient, but it is to be remembered that in the majority of cases the forms are mixed.

1. The spastic form is undoubtedly the most common, and it has given to the disease its name. Cramp of some muscle or muscles was present in over half of Berger's cases of writers' cramp, and in thirty-one of Lewis' forty-three cases of telegraphers' cramp. The muscles of the thumb and first three fingers are oftenest affected, and in some cases the flexors, in some the extensors are chiefly involved. Canstett bases a classification upon this fact. In telegraphers' cramp it is the extensors, but in writers' cramp the flexors, that are mainly affected. The thumb, or fore-finger, or the little finger alone may suffer from the spasms. The pronators and supinators are quite often involved, and Berger notes a case in which there was spasm only in the pronator radii teres. Duchenne and Weir Mitchell report cases of "lock-cramp," in which, on attempting to write, the hand closes tightly in strong contraction, and remains so for a considerable time. This symptom suggests the hypertonia of Thomsen's disease. As stated, associated spasmodic movements sometimes occur in the neck muscles, or in the other arm.

With the spasm, there is also inco-ordination so far as writing movements are concerned, and this fact is quite as important in producing the bad writing as the spasm. The inco-ordination is apparently of the motor, or at least central, type, and is not due to anæsthesia of the muscle-sense, as in locomotor ataxia.

2. The paralytic form, or that type in which muscular feebleness is the dominant symptom, ranks next in frequency. In Berger's 64 cases, 24 were purely spastic, 10 paralytic, 8 tremulous, and 22 mixed.

In the typical paralytic form the patient, as soon as he begins to write, feels an overpowering sense of weakness and fatigue in the fingers and arm. The fingers themselves loosen their grip, and the pen may drop from the hand. Powerful impulses of the will and change in the mode of holding the pen, enable the sufferer to continue, but the arm aches, and finally is absolutely painful, and weakness and fatigue compel the writer to desist. Sometimes the paretic condition is succeeded by the spastic.

Many of the cases of paralytic writers' cramp are not true examples of the neurosis, but are rather cases of neuritis of a rheumatic or other type. Poore's tables show that nearly a third of the cases of impaired writing power are really forms of neuritic paresis. In this paralytic form the muscles of the thumb and the interossei are oftenest affected. The first dorsal interosseus and the abductor pollicis may be independently attacked. The writing, while writing is still possible, is fainter, and the characters larger as well as less perfectly formed. In the true cramp, the hand or arm muscles show no paresis, except in the act of writing; but in the neuritic impairment of writing, the paresis is absolute.

Duchenne records a case in which the lateral movements of the hand and arm along the paper were impossible. After writing a few words the patient had to draw the paper from right to left. In this instance the deltoid and infraspinatus were paralyzed.

3. The Tremulous Type. This, though rare, is very characteristic when present. The patient, when attempting to write, observes a tremulous movement of his hand and arm. This ceases when his attempts to write cease. The tremor usually affects most the fingers used in penprehension, but it generally spreads to the forearm, and may even involve the entire extremity. An oscillatory or lateral tremor, due to involvement of the pronators and supinators, has been observed by Cazenave.

The tremor, as may be seen, is of the character known as "intention-tremor," such as is observed in disseminated sclerosis. It is much shorter in range and more rapid than the tremor of that disease, and corresponds practically more with the ordinary fatigue tremor often seen after great muscular exertion.

General Symptoms.—Writers' cramp is essentially a motor neurosis, and its leading symptom is the impairment of a motor function. Other symptoms, however, both general and local, are always associated with it. These are mainly (1) psychical and (2) sensory, more rarely (3) vaso-motor, and (4) trophic.

1. Psychical Symptoms. The patient is often nervous, emotional, and mentally depressed at times. He suffers from insomnia and vertigo. Patients are generally unwilling to admit that there is any other trouble than the local one, and only careful examination may bring evidence of constitutional trouble. There are cases of purely mental "writers' cramp." Thus, Shever gives the history of a man forty-two years of age, who was suddenly attacked with vertigo. Next day he found that he could not write, because an inexplicable feeling of fright seized him when he began to form letters. His condition became ameliorated, so that he could write for a time, when again the fear would seize him. He could write with his eyes closed. There were no other symptoms. Dr. Morris J. Lewis, who has investigated the subject of telegraphers' cramp more thoroughly than anyone else in this country ("Pepper's System of Medicine," vol. v., p. 520), states that telegraph operators who suffer from cramp, are sometimes unable mentally to grasp the proper number of dots and dashes composing certain Morse characters. They also have special difficulty in making these characters and of recognizing them by sound. The dot-characters give the most trouble.

2. Sensory Troubles. These consist of pain, sense of fatigue, feelings of numbness, prickling, pressure, weight, tension, constriction, etc. Hyperæsthesia, and more rarely anæsthesia, are also observed.

The most common sensory symptom is that of aching and fatigue, and this is usually confined to the arm. The pain is especially noticed in connection with the paralytic form (Zuber), and it generally follows the course of the nerves. The radial and median are those chiefly involved, while very little pain is ever felt along the ulnar. The arm is tender along the course of the nerves, and there may be tenderness over the cervical vertebræ. Erb had a patient who suffered from a steady pain over the left frontal region, almost exactly, it seems, over the probable writing-centre. M. Meyer calls attention to the presence of pain and tenderness, at times, in the apophyses. Disturbance of the common sensibility of the muscles of the arm has been observed by Poore. In fine, the involved extremity may be affected with a great variety of subjective sensory disturbances.

3. Vaso-motor, Trophic, and Secretory Disturbances. The condition known as *digiti mortui* has been observed, coming on paroxysmally. It is a symptom which the general neurasthenic state helps to produce. When the nerves are involved, decided vascular changes may occur, such as passive congestion of the hand and arm, with swelling and turgescence of the fingers, and a sensation of throbbing. In bad cases the fingers will look as if they had chilblains. Local sweating, dryness of the skin, and cracking of the nails, all are conditions which may follow impairment of writing-power from neuritic causes.

Electrical Reactions.—The results of observations upon the electrical reactions of the affected parts are somewhat contradictory. Ordinary tests will, as a rule, reveal very little change. Sometimes there is a quantitative increase, sometimes a decrease, of irritability to both forms of current. The increase occurs in the earlier stages, the decrease in the later. The contraction formula, Ka C C > An C C, is not changed, unless a decided neuritis complicates or causes the trouble. An increase, or modification, of electro-muscular sensibility has been noted. The electrical examinations, therefore, are only of value in excluding a neuritis, or possibly in determining the stage of the disease.

Course and Duration.—Writers' cramp is a chronic disease. It begins insidiously, and attacks one group of muscles after another, as each is brought into play by new methods of writing. If the left hand is used, that, too, is liable to become affected. The course varies, however; for a time progress may be arrested, or improvement set in. When the disease becomes well established, it will most often last a lifetime. For example, a pianist, while yet a young man, was attacked with pianists' cramp. He changed his profession, and gave up piano-playing; yet, at the end of five years, if he attempted to use the piano, the cramp still attacked him.

Prognosis.—The prognosis is unfavorable, yet not so much so as has once been thought. Undoubted cases of complete recovery have been reported, and Berger's statistics place the per cent. as high as eight. I have observed a case of complete cure of telegraphers' cramp, and one of writers' cramp.

The prognosis is much more favorable if the patient begins treatment early, and before marked spastic symptoms are present. It is believed that certain modern therapeutical methods, to be referred to later, will also modify the prognosis. Some patients who suffer from a mild form of the trouble manage, by the help of instruments or special pens, to do their work for years.

The more acute the disease, and the more evidently peripheral and neuritic its origin, the better the prognosis. Severe sensory disturbances are of more favorable omen than severe motor trouble. Perhaps in about one-fourth of the cases, patients who use their sound arm will not be affected in it.

The facts stated regarding the cause, physiology, and general symptomatology of writers' cramp apply to the other forms of functional neuroses. A few special details, however, will be given regarding these. The most common and important are musicians' cramp and telegraphers' cramp.

Musicians' Cramp.—Under this head we include pianists' cramp, violinists' cramp, flutists' cramp, and the cramp of clarionet players.

Pianists' cramp occurs usually in young women who are studying to become professionals, or who are espe-

cially hard-working and ambitious. The absurd "Stuttgart method" of teaching the piano, in which the motions are confined as much as possible to the fingers, predisposes especially to this disease. The symptoms are those of fatigue, pain, and weakness. The pains are of an aching character. They are felt in the forearm especially, but extend up to the arm and between the shoulders. Spasmodic symptoms are rare. The right hand is oftener affected, but both hands eventually become involved.

Violinists' cramp may attack the right hand which holds the bow, or the left hand which fingers the strings, but more often the left hand is affected. The sufferer feels at first a sense of fatigue and uncertainty in the fingers and arm, then pain, and finally some spasmodic movements occur.

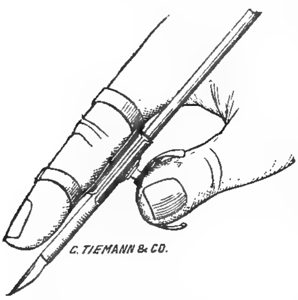

FIG. 3103. – Mathieu's Apparatus. The pen is moved by the thumb and index-finger.

Clarionet players sometimes suffer from cramp of the tongue (Strümpell), and of the laryngeal muscles (Eichhorst).

Flute players, according to observations related to me by Dr. T. H. Kellogg, suffer not very infrequently from slight laryngeal spasms. The same observer has noted similar spasms in elocutionists. The term mogophonia is applied to this trouble.

Telegraphers' cramp was first described by Simon, in 1878 (*Comptes rendus Soc. de Biol.*, 6, 92–96). It has been noticed by English and Scotch physicians, and has been exhaustively studied by Dr. Lewis, of Philadelphia (*loc. cit.*). Dr. Beard also made some studies of it. It affects especially those operators using the Morse system, an instrument which is still the one most widely in vogue. Contrary to the opinions of previous writers, Dr. Lewis believes that this neurosis is not a rare one, and is destined to become more frequent. Considering that there are perhaps less than thirty thousand telegraph operators in the country, as against the vast army of clerks, copyists, writers, etc., the fact that Dr. Lewis was able to collect forty-three cases of telegraphers' cramp is significant.

Dr. W. H. McEnroe, of New York City, who has had a largely personal experience with telegraph operators and their diseases, informs me that the cramp is rare, the proportion being about one in every two hundred.

The technical name, among operators, for the cramp is "loss of the grip." In telegraphing, the extensors of the wrist and fingers are called most into play, and hence are most and earliest affected. The symptoms come on very slowly, the thumb and index-finger being first affected. The victim finds that he cannot depress the key on account of spasm in these muscles, and he finds most difficulty in making the dot-characters, such as h (. . . .), or p (. . . . .), or z (. . . .). When the flexors are most affected, the key is depressed with undue force, and a dash is made instead of a dot. Sufferers from the "loss of grip" generally suffer from writers' cramp also. Most cases occur between the ages of twenty and thirty. Males and females are almost equally affected—perhaps there is a preponderance in favor of females; and, according to Lewis, the disease attacks them earlier than it does males. While spasm is usually present, the disease may show itself simply in pain, paresis, and incapacity to co-ordinate the muscles.

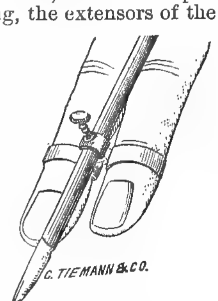

FIG. 3104.—Mathieu's Apparatus. The pen is held by the index- and middle-fingers.

In *sewing spasm*, which affects tailors, seamstresses, and shoemakers, clonic and tonic spasms attack the muscles of the hands on attempting to use them in the regular work. Tailors who sit cross-legged sometimes suffer from a peculiar spasm on assuming this position. It is possible, however, that these are cases of tetany, and not of the functional neurosis under consideration.

Smiths' spasm, crampe des forgerons, hephæstic hemiplegia, appears to have been observed only by Duchenne and Dr. Frank Smith (*Dictionnaire encyclop. des Sciences médicales*, t. x., p. 775). It occurs in persons engaged in pen-blade manufacturing, saw-straightening, razor-blade striking, scissors-making, file-forging, etc. In doing this work they have to use a light or heavy hammer, with which strokes are delivered very rapidly and carefully. After a time spasmodic movements occur in the arm used, and the arm falls powerless. As in the cases reported there are generally hemiplegic symptoms, and also neuralgias, vertigo, and other cerebral troubles, the disease cannot be a pure "professional" neurosis.

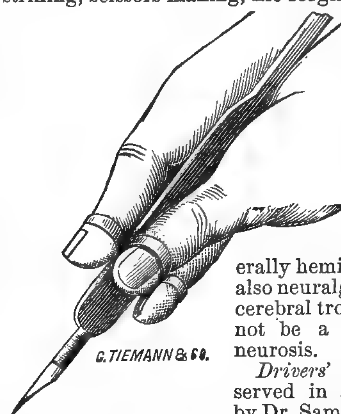

FIG. 3105.—Cazenave's Apparatus. The index, middle-finger, and thumb are immobilized.

Drivers' spasm has been observed in a veterinary surgeon by Dr. Samuel Wilkes ("Diseases of the Nervous System"). The patient had to drive hard-bitted horses for many hours daily. Finally his arms were attacked with cramps whenever he took the reins.

Milkers' spasm is an extremely rare affection, which was first described by Basedow and seems to occur in milkmaids, never in milkmen (*Casper's Wochenschr.*, 1851). Berger is the only other author who reports a case.

Cigarmakers' cramp must be an exceedingly rare affection. I can find reports upon it by only two observers, O. Berger (*Berlin. klin. Woch.*, 1873, No. 21), and Koster (*ibid.*, 1884).

Watchmakers' cramp (O. Berger, S. Weir Mitchell) and *Photographers' cramp* (H. Napias: *Revue d'Hygiène*, i., 927, 1879), are also to be regarded merely as pathological curiosities.

Ballet-dancers' Cramp.—Under this name certain painful and paralytic troubles occurring in ballet-dancers, especially premières danseuses, have been described by Schultz, Onimus, and Kraussold. It does not appear that

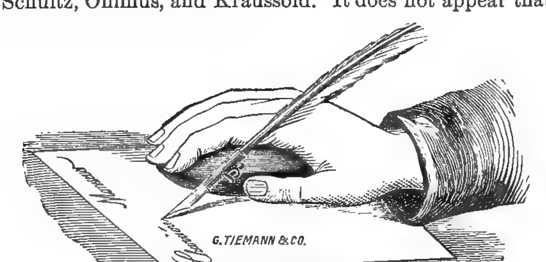

FIG. 3106.—Duchenne's Apparatus.

the trouble is really a co-ordinative functional one, but is rather neuralgic, or the result of local strain upon the parts.

The list of professional neuroses is made to include, besides those above given, cramps and co-ordinative troubles affecting artificial flower-makers, billiard-players, dentists, hide-dressers, electrical instrument-makers, stampers, turners, sewing-machine girls, money-counters, weavers, painters, and pedestrians.

In most of these cases there is probably some inflammatory affection of the nerves, or ligaments, and not a true central neurosis.

The Diagnosis of well-marked cases of writers' cramp presents no difficulty. In the earlier stages, however, it may be confounded with a large number of disorders, viz., post-hemiplegic chorea, hemiataxia, progressive muscular atrophy, progressive locomotor ataxia, various forms of tremor, lead paralysis, rheumatoid arthritis, neuritis, cerebral and nerve tumors, and tenosynovitis.

In many of these cases it is only necessary to bear in mind the history of the disease in order at once to reach

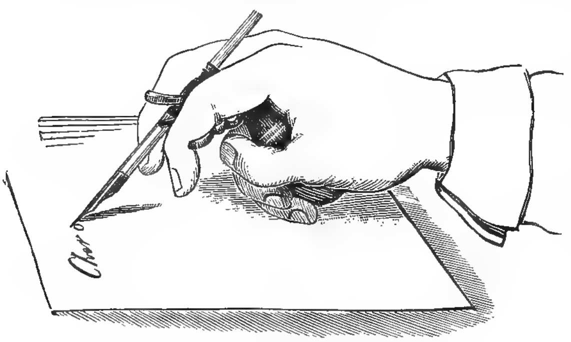

FIG. 3107.—Cazenave's Apparatus, Modified by Duchenne.

a diagnosis, for in writers', or telegraphers', or musicians' cramp the symptoms are localized in a single, or at most two, extremities.

Dr. Weir Mitchell has called attention to the fact that a person may have a very slight and transient cerebral hemiplegia, followed later by post-hemiplegic disorders of movement, which may be mistaken for writers' cramp. Such troubles occur either much earlier, or somewhat later, in life than the writers' cramp, and the motor disturbances affect the leg and possibly the face as well as the arm. Dr. Lewis (loc. cit.) cites from Dr. Weir Mitchell's note-books two cases, illustrating the fact that some cases of slight arm paralysis, due to small lesions affecting the arm-centre of the cortex, may be mistaken for functional paralysis.

Some occupations which call into play repeatedly and continuously the same group of muscles, produce in them a gradual atrophy. This has been called "professional muscular atrophy" by Onimus. I have seen it occur in the thenar muscles and deltoid of a butcher, whose work obliged him to handle a cleaver for many hours daily. I have also observed atrophy of the thenar muscles in a lapidary. The act of writing may induce a progressive paresis and atrophy of the muscles of pen-prehension. These occupation muscular atrophies are, I believe, myopathic in origin; they are not accompanied with the central vaso-motor or secretory disturbances of true spinal progressive muscular atrophy, and they are characterized by a rapid improvement or arrest in progress under rest and treatment. Dr. Lewis cites some cases to show that in the earlier stages, or in mild types of multiple sclerosis, or irregular diffuse sclerosis of the brain and cord, motor disturbances occur which may be mistaken for writers' cramp.

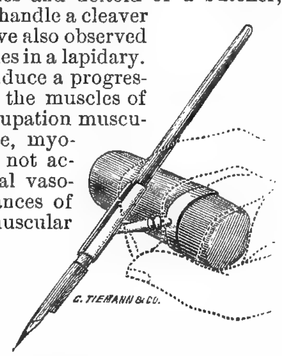

FIG. 3108.—The Pen is Attached to a Block, which is Grasped by the Hand in the Position Shown by the Dotted Lines.

As already stated, the diagnosis of the various "cramps" is practically easy when any ordinary care is exercised in examination; and, after all, the most important point for the physician to determine is the form of impaired writing-power from which the patient suffers.

If there is a great deal of pain in the arm, with tenderness along the course of the nerves; if there is decided change in the electrical reactions; if there are sensations of tingling, numbness, etc.; and if the patient shows an absolute loss of power in the various groups of muscles, with some incapacity for doing other acts besides the one with which he is specially concerned; then the trouble is undoubtedly peripheral and due largely to an underlying neuritis. The prognosis in these cases is much more favorable. If, on the other hand, the disorder comes on in persons who have not done an excessive amount of writing; if it is associated with nerve-strain; if the electrical reactions are but slightly changed, the sensory symptoms slight, and the motor inco-ordination marked, limited to the special class of work, and not accompanied with absolute paresis, the disorder is central, and needs both a different treatment and prognosis. It is these cases that form writers' cramp proper, although no doubt neuritic and central forms are associated, or the former may run into the latter.

For convenience I append a diagnostic table showing the differential points between central and peripheral writers' cramp:

IMPAIRED WRITING-POWER, ETC., MAINLY OF NEURITIC ORIGIN.	IMPAIRED WRITING-POWER, ETC., MAINLY CENTRAL IN ORIGIN.
1. Caused by excessive writing.	1. May be no marked excess of writing; but a neurotic history is obtained.
2. Marked sensory symptoms of tenderness over nerves.	2. Sensory symptoms subordinate. General nervousness and mental depression are noted.
3. Electrical reactions show increased irritability, possibly qualitative changes.	3. Electrical changes slight.
4. Paresis of certain groups of muscles. This may be shown in inability to do other co-ordinate acts.	4. Paresis but little marked or absent. Patient can do all other kinds of muscular work easily.

Prophylaxis and Treatment.—Although the amount of writing done at the present day is enormously increased, there is not a corresponding increase in writers' cramp. This is due to the introduction of gold and stylographic pens, type-writers, and better pen-holders. Persons who do a great deal of writing, if they find any signs of impending cramp, should use some of these instruments as much as possible. Stylographic pens are less liable to lead to trouble in writing, because not so much prehensive power is needed in their use. The same is true to a less extent of gold pens. The pen-holders should have a slightly roughened surface, of cork or soft rubber. Large-handled pen-holders are held more easily. Small, smooth, metal or hard-rubber holders are to be avoided. Pencils are not so good as pens, because they require more prehensive force. The paper written upon should be smooth. The best style of writing is that already referred to as the American, the movements being made both with the arm and the fingers. Many nervous persons have a bad habit of gripping the pen very tightly, and pressing down on the paper with excessive force. Fatigue soon results, and painful sensations develop in the arm. Proper attention should be paid to the position of the paper written upon, the height of the desk, the light, and the sleeves of the coat or dress. The paper should be laid at an oblique angle to the edge of the desk, and not at a right angle as many writing teachers are accustomed to direct. As some cases of "cramp" are undoubtedly cerebral, it is very unwise to attempt any extraordinary exploits in writing, or to work with the ambition to put the writing capacity to the utmost test. Cramp is often dated from days when such extra work is done. Sensations of weariness and

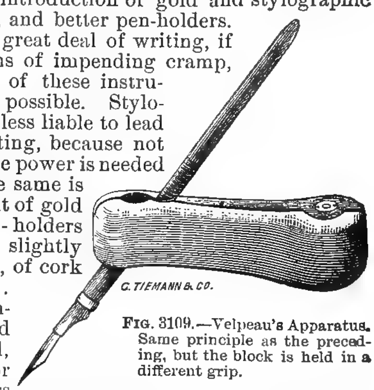

FIG. 3109.—Velpeau's Apparatus. Same principle as the preceding, but the block is held in a different grip.

slight premonitions of cramp should be watched and promptly treated. It seems to be agreed that no modification of the telegraphers' key is of much value in preventing "loss of grip." Telegraphing with the finger-movement alone, the wrist and fore-arm resting on the table, is a bad method that should be avoided.

When the cramp is fully developed, by far the most essential thing is prolonged rest, and the physician should always consider the question whether the patient should not abandon his occupation altogether. If complete rest is not attainable, the various methods of getting partial rest are as follows :

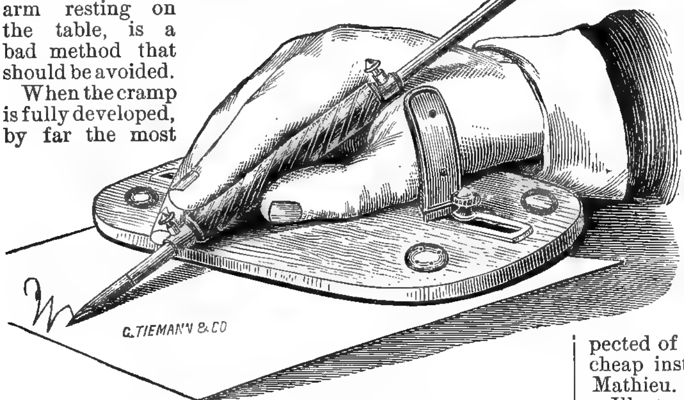

Fig. 3110.—Apparatus of MM. Charcot and Cazenave. The hand is fastened to a board, as is also the pen. The board slides along upon the paper.

1. Getting a new form of pen and pen-holder.

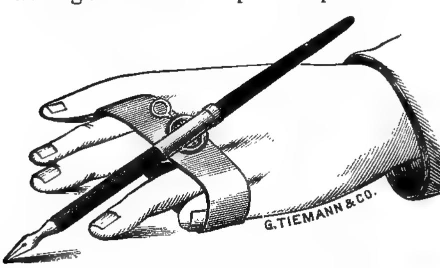

Fig. 3111.—Nussbaum's Apparatus. It consists of a bracelet of hard rubber, upon which the pen can be fastened at any length. In order to hold it firmly, the fingers have to be spread out. A piece of flannel is placed between the hand and the paper.

2. Holding the pen in a different way.
3. Using the unaffected arm.
4. Using some form of mechanical appliance.

With regard to 1 and 2, enough has already been said.

3. As a rule, if the unaffected arm is used, it soon becomes involved also. This is not always the case, however.

4. The mechanical appliances are splints, rubber bands around the wrist, and various instruments contrived to prevent spasm and throw the work of writing on new and larger groups of muscles.

Instruments for writers' cramp are very numerous. The first one was invented by M. Cazenave, in 1846, and simply fastened together and immobilized the thumb, forefinger, and middle-finger. M. Mathieu constructed several instruments which relieved the hand of the necessity of pen-prehension and immobilized the fingers—a matter of especial importance when there is paralysis. MM. Vulpian and Charrière devised a series of instruments in which the pen is fastened at various angles to a ball or bar, which latter is grasped by the hand. Prehension and the writing-movements are thus performed by a different and larger number of muscles.

As will be seen, the French have been particularly prolific in originating these instruments.

Mr. Charles Thurber, of Philadelphia, himself a sufferer from writers' cramp, invented an instrument which he called the "Kaligraph." It consists essentially of a pantograph so arranged that, by making the letters very large at one angle, they are reduced to a natural size at the other. Besides this, the writing is done entirely without any effort of pen-prehension, and may even be accomplished by attaching the directing pin to the wrist. The principles involved, therefore, are good, and practically it has been successful. It is, however, cumbersome and expensive. Professor Nussbaum has devised an apparatus involving a new principle. In order to write with it the fingers must be separated, and some effort must be made with the extensors, while none at all is made by the flexors of the fingers and the wrist. Hence, new sets of muscles are actively innervated while those ordinarily used are rested. Practically this instrument is often very helpful. All the various instruments have been of service, or have even been curative in some special cases, but not too much must be expected of them. As a rule, they are only palliative. A cheap instrument that may prove satisfactory is that of Mathieu.

Illustrations of the different instruments are given on this and the two preceding pages.

In the medical treatment of writers' cramp, the two most important agents are massage and electricity.

By massage only very mediocre results were obtained until greater attention was drawn to it by Mr. J. Wolff, a writing-master of Frankfort-on-the-Main. This gentleman has cured many cases, though not all that he has tried (Berger), and he has secured many testimonials for his method. It has only been fully described, however, by Drs. Schott and Stein, the former of whom disputes with Mr. Wolff the honor of devising the method. The treatment, as described by Schott (G. W. Jacoby : "Massage in Nervous Diseases," *Journal of Nervous and Mental Diseases*, June, 1886), consists of a system of gymnastics and massage.

The gymnastics consist of movements performed by the patient alone, and movements executed with the co-operation of the operator.

The first are performed by the patient during from twenty to thirty minutes, rarely for forty-five minutes. These movements consist of gymnastics of the fingers, extension, flexion, abduction, and adduction being performed, and the thumb being exercised separately. After this the same four motions are executed at the wrist-joint, then extension and flexion of the forearm, and ultimately the arms themselves are exercised in the same manner and are to be lifted over the head. Each single exercise is to be performed from six to twelve times. After each motion a pause is to be observed.

The opposed movements are to be carried out in the same manner, except that the operator must carefully resist their execution as though he were endeavoring to force the patient to perform a motion just the reverse of his intentions. Regularity of pressure is to be observed in this, so that the same amount of force is always used, and so that the pressure does not vary in intensity from

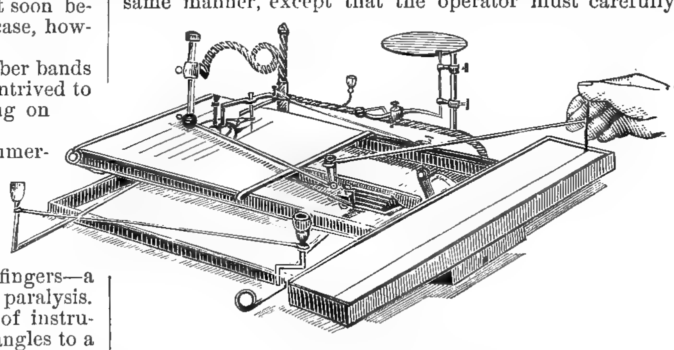

Fig. 3112.—Thurber's Kaligraph.

moment to moment. The time to be devoted to these opposed movements should be the same as that for the unopposed ones. According to the intensity of the affection, the exercises must be repeated two to three times daily.

The massage itself consists of two parts—nerve and muscle massage. The nerve-massage is effleurage along the course of the nerve-trunks, the median, ulnar, and radial, going upward to the axillary and cervical plexuses. This effleurage lasts about ten minutes. Following this is the muscle-massage. This consists of pétrissage, beginning with the hand and ending at the shoulder. The duration is the same as that of the last movement. One sitting a day has always proved sufficient.

Wolff, in addition, uses "a peculiar method of writing instruction," and employs rubber bands and rings in his manipulations. Wolff is by no means alone in getting good results from massage.

Electricity ranks second to massage in the treatment of professional neuroses. The faradic current may be used when the affection is paralytic, but the galvanic current is usually more efficacious. The polar method is to be employed, the anode or sedative pole being placed over the cervical spine, and the kathode over the various muscular groups affected. A stable current of five to ten milliampères for from ten to fifteen minutes is indicated. Galvanization of the sympathetic is recommended by some. Galvanic belts applied about the arm seem irrational enough, but have been known apparently to effect cures. Vigouroux claims to have cured a case by static electricity.

Lotions containing muriate of ammonia, liniments, hot and cold douches, the cautery, all have been recommended in professional neuroses. Tenotomy was once employed, but has been abandoned. Very little can be expected of drugs. The most trustworthy are: atropine, strychnine, the iodides and bromides, and cod-liver oil. It should be remembered that sometimes the disease is almost purely cerebral, and then an anti-neurasthenic treatment is called for. But in other cases, when the disorder is largely peripheral, the usual treatment for a low grade of myo-neuritis must be employed.

Charles Loomis Dana.

PROPYLAMINE. A body isomeric with *trimethylamine*, with which it is often confounded. See Trimethylamine.

PROSTATE, THE. The prostate gland (Gr. προστάτης, from προ and ἱστάναι, to set, or ἵστημι, I stand) derives its name from its position at the entrance to the bladder.

ANATOMY.—The prostate is a body largely glandular in character, and in shape much like a Spanish chestnut. In the upright position of the body it lies just below the bladder and behind the symphysis pubis. The base of this heart-shaped gland is in contact with the bladder and vesiculæ seminales, while the apex rests upon the posterior layer of the deep perineal fascia; the anterior surface looks toward the pubes, and the posterior surface rests upon the anterior rectal wall.

The urethra, as it leaves the bladder (pars prostatica urethræ), traverses the prostate from near the middle of its base to its apex, and rather more than one half of the gland lies behind the canal.

The prostate weighs from five to six drachms, and measures approximately one inch and a half in length, one and a half to two inches in breadth, and one inch in thickness (antero-posterior diameter). Slight longitudinal furrows along its anterior and posterior surfaces, show an indistinct tendency toward a division into two lateral lobes, although the two halves are structurally continuous with each other. In this connection it is worthy of note that in some animals the prostate consists of two separate lobes.

That portion of the gland lying between the ejaculatory ducts and the urethra (pars supra-montana, Mercier), is usually known as the middle lobe (Home). Situated upon the floor of the urethra, just at the entrance to the bladder, it often forms a little prominence continuous with an elevation of the vesical floor (uvula vesicæ).

The portions of the gland behind and in front of the urethra, connecting the lateral lobes, are known as the posterior and anterior commissures.

The substance of the prostate is made up mainly of three tissues: 1, Glands; 2, unstriped muscular fibres, and 3, fibrous tissue.

The glands are of the acinous variety, and are most abundant in the lateral portions of the organ, their ducts coalescing and opening along the floor of the urethra. The muscular fibres are disposed in circular bands which are continuous at the junction of the bladder with the circular fibres of that viscus. Hyrtl also describes a system of these fibres radiating from the caput gallinaginis. The fibrous tissue forms a firm enveloping capsule which sends off-shoots through the substance of the gland.

Just below the point of entry of the urethra the two ejaculatory ducts enter the prostate, one on each side, and running forward through its substance and converging, they enter the floor of the urethra.

The prostatic urethra (pars prostatica urethræ) is slightly narrower where it enters and leaves the gland than it is within it. The hollowed floor of this portion of the canal is called the sinus prostaticus, and is divided into two equal furrows by a longitudinal ridge (verumontanum), the end of which furthest from the bladder is composed of erectile tissue, and is capable of considerable dilatation into a little round prominence which, with the verumontanum running back from it, presents a fancied resemblance to the head of a snipe—hence its name *caput gallinaginis.*

On the top of this little eminence is the opening of a minute sac—the utricle or sinus pocularis—which is thought to be the analogue of the uterine cavity in the female. Close to the edge of this sinus, and sometimes within it, are the orifices of the ejaculatory ducts. Along the sides of the verumontanum open the prostatic glands proper, to the number of from twenty to thirty.

The prostate is enclosed in a tough fibrous capsule which is a part of the pelvic fascia. Besides its attachments to the bladder and deep perineal fascia, it is further held anteriorly by the pubo-prostatic ligaments, and posteriorly by the recto-vesical fascia. Its slight mobility is provided for by the levatores prostatæ—muscular bundles, really parts of the levator ani—which, arising from the posterior surface of the pubes, are inserted along the lateral borders of the gland.

Its blood-supply is derived from the internal pudic, the vesical and hæmorrhoidal arteries, and the veins which form a plexus around the gland empty through the hypogastric vein. The nerves are branches of the hypogastric plexus of the sympathetic.

PHYSIOLOGY.—The prostate is a sexual gland. After birth it remains in a quiescent state up to puberty, when it begins to increase in size and development. It attains its full growth about the twenty-fifth year.

The secretion of the glands, which are especially active during sexual excitement, is a clear fluid of neutral reaction, with a specific gravity of 1.010.

It is especially rich in chloride of sodium (one per cent.) and as solutions of this salt are known to excite the spermatozoa to movement, its presence in the prostatic fluid is thought by some to perpetuate their activity. Probably the most important function of this secretion is, however, as a lubricant to the urethra.

The prostate, further, in its character as a muscular organ, acts as an involuntary sphincter of the bladder. As the urine accumulates a point is finally reached at which the tension of the detrusor urinæ muscle pulls open the rings of involuntary fibres around the neck of the bladder and allows the urine to enter the pars prostatica urethræ. Its presence there causes an urgent desire to urinate, and the escape of the water is then only prevented by the compressor urethræ muscle, which is the voluntary urinary sphincter. If this muscle does not relax and allow urination to be completed, the prostate closes down and forces the contained urine back into the bladder, where it stays until the further increased tension brings on another "besoin d'uriner."

Malformations.—The prostate may be wholly wanting,

in connection with a general lack of development of the urinary organs.

In exstrophy of the bladder there is no roof to the prostatic urethra, and the gland-ducts may be seen opening through the mucous membrane over the site of the organ.

Injuries and Wounds.—The deep-seated position of the prostate makes it little liable to injury from without. In severe crushes of the pelvis with fracture about the pubes, it may be wounded. In perineal lithotomy it is always incised, and often somewhat contused by the extraction of the stone. If the crushing and laceration of the parts have not been serious, healing usually takes place kindly.

Injury of the prostate occasionally results from the passage of instruments through the urethra. This occurs most commonly in cases of hypertrophy, where the irregular enlargement of parts of the gland has made the canal tortuous.

A specimen in the Museum of the Harvard Medical School, shows a very much enlarged middle lobe which so obstructed the entrance of the catheter, that the instrument had been forced directly through it and had entered the bladder beyond.

The knowledge that such injuries are possible should lead to their avoidance. Much force is never needed in the passage of an instrument which is properly guided; but a thorough understanding of the nature of the possible obstacles, and considerable patience and care in overcoming them, are necessary to success in these cases.

INFLAMMATION OF THE PROSTATE — PROSTATITIS — may be either acute or chronic.

Acute prostatitis is commonly the result of the extension of an inflammation from adjacent parts.

A gonorrhœal urethritis is by far the most usual exciting cause. In this case the inflammation runs back along the urethra to the prostate. That this is not the usual course of a gonorrhœa is due to the protection afforded by the constrictor urethræ muscle. This sphincter, surrounding the membranous urethra, prevents the discharge from penetrating to the prostate and bladder, and usually protects these deeper parts from participation in anterior inflammations. Occasionally the passage of an instrument, or the forcing of an injection through the constrictor, may convey infective discharges past this natural barrier.

A non-specific urethritis or an inflammation of the bladder may, in similar manner, extend to the prostate. Acute inflammation of this gland may also be excited by mechanical irritation. This may proceed from the passage of instruments, from the application of caustics, from the use of strong injections, from the presence of calculi in the bladder or prostate, from accidental injuries, or from operations.

Among other causes cited as occasionally giving rise to prostatitis, may be mentioned sexual abuses, acrid irritating conditions of the urine, the use of stimulating diuretics such as cantharides and turpentine, the abuse of stimulants, and the presence of inflammation in the rectum. Probably these conditions are rarely, if ever, competent to excite an acute prostatitis in a healthy state of the gland, but only act to aggravate an already existing inflammation.

A stricture of the urethra greatly aggravates any deep inflammation of that canal, and makes its extension to the prostate much more liable to occur.

Pathology. In acute inflammation the prostate is much congested, with great swelling and œdema, which extend to the surrounding parts. The prostate itself may be enlarged to three or four times its natural size, and even with this degree of inflammation, resolution and a return to a comparatively normal condition is possible.

If, however, the inflammation runs a more acute course, it may lead to the formation of abscesses, which, starting as minute points of pus, may gradually enlarge and coalesce until, in an extreme case, the whole organ may be reduced to one abscess-cavity.

Spontaneous opening may take place backward into the rectum, into the urethra, or bladder, and the pus may even occasionally find its way down through the ischio-rectal fossa, or into the perineum, and point externally. Rarely, the abscess may open into the peritoneal cavity, or into an adherent coil of intestine.

Symptomatology. The prominent symptoms are pain deep in the perineum and in the rectum, with tenesmus of the bladder and the rectum. Urination is very frequent, and is accompanied by great pain, especially during the passage of the last few drops of water, which are frequently colored with blood.

Accompanying these local symptoms, there is usually considerable fever, which may, or may not, be ushered in by a chill. There is, also, often severe pain in the back, loins, and thighs.

As the inflammation increases the pains become even more severe, the urine in its passage scalds intensely, the pressure and throbbing pain in the rectum become very distressing, and defecation, which is constantly desired, is, when it happens, a new source of suffering.

The stream of urine becomes small and hard to start, owing both to the swelling of the prostate and to the spasmodic contraction of the constrictor urethræ muscle, and finally complete retention may result.

If a gonorrhœal discharge previously existed, it may disappear at the onset of prostatic inflammation, or it may be changed into a slight mucous discharge.

There is usually a good deal of tenderness in the perineum, and sometimes also close above the symphysis pubis. A rectal examination is difficult on account of the extreme sensitiveness of the parts, accompanied by spasm of the sphincter muscle.

If the inflammation gives rise to an abscess, its formation is often heralded by rigors with high fever. If the abscess breaks into the urethra or bladder, there may be a sudden escape of pus in the urine, with an improvement of the general symptoms.

If the pus-cavity attains any considerable size, its character may be made out through the rectum, where it is to be felt, first as a hard, boggy swelling, which later softens and gives evidence of fluctuation.

If the abscess extends into the loose cellular tissue along the rectum, pyæmic symptoms may develop, and in case of rupture into the peritoneal cavity the characteristic symptoms of peritonitis will come on abruptly, with a speedily fatal issue.

Treatment. Absolute rest is the first and most important measure when acute inflammation of the prostate makes its appearance.

The patient should keep in a horizontal position with the hips somewhat raised.

If severe pain is present—especially if frequent spasms of the bladder are aggravating the inflamed gland—opiates should be given; and it is to be borne in mind that these, by inducing rest from spasm, exert a really curative effect. Morphia and atropia subcutaneously, or opium and belladonna suppositories, may be administered under these circumstances.

All irritations from instrumentation, injections, or stimulating diuretics, should be avoided.

The bowels should be kept gently open by aperients, if necessary, and this point should be carefully looked after when opiates are being used.

The urine should be rendered as unirritating as possible by the use of diluents and alkaline diuretics, and nourishment should be given in a bland, unstimulating form. Farinaceous gruels, milk, and light broths may form the bulk of the diet. Alcohol should be entirely avoided in the acute stage of the disease.

If at the outset the fever runs high, it may be somewhat mitigated by the use of quinine or some more temporary febrifuge, such as aconite or antipyrine. Late in the disease, when it has run a severe course—especially in case of exhausting suppuration—strong concentrated foods and alcoholic stimulants may be required.

Locally, all possible measures for limiting the severity of the inflammation should be employed. In an early stage of the disease, leeches applied to the perineum may be of considerable service. From six to eight should be

put on along the raphé and close to the anus. The bleeding may be encouraged, especially in plethoric persons, until from fourteen to sixteen ounces have been withdrawn.

Hot applications, either by fomentations or by hot water bottles, to the perineum and over the pubes, are useful in diminishing pain and spasm, and probably assist somewhat in lessening the inflammation. Hot hip-baths are recommended for this same purpose; but the exertion and the unfavorable position required for these, add so much to the pelvic congestion as to greatly diminish the otherwise favorable effect of the heat. If used, they should not be prolonged for more than five or eight minutes, as the maximum effect on the surface is produced in that time.

If retention of urine occurs, it must be relieved by the careful introduction of a small, soft catheter (Nos. 12 to 14 French scale).

Sometimes, when there is a spasmodic stricture at the compressor urethræ, a soft catheter will not pass, and a stiff instrument must be used, requiring, of course, the greatest gentleness of manipulation.*

When the retention persists and requires repeated catheterization, an instrument tied into the bladder (*sonde à demeure*) will often cause less irritation than would its frequent introduction.

The possibility of abscess formation is always to be kept in mind, and the condition of the gland should be watched by rectal examinations. If fluctuation is made out, the abscess should be opened at once. This may usually be done through the rectal wall with a curved *bistouri caché*, and the opening should be rather a puncture than a long incision. This is for the purpose of avoiding hæmorrhage; and it is a good plan, with this same object in view, to make a careful examination before the puncture, to see that no vessel of any size in the rectal wall stands in danger of injury by the knife. In case of bleeding, ice pellets should be introduced into the rectum, and if these fail, pressure should be applied by a thorough plugging of the lower part of the bowel.

If examination shows that the abscess is working toward the perineum, it may be opened by an incision from that direction, and thus a urethro-rectal fistula with prolonged suppuration may be avoided.

When the abscess communicates with the rectum thorough irrigation of the bowel should be carried out, and an antiseptic, free from poisonous properties, should be selected, on account of the absorptive power of the rectal mucous membrane.

If the disease ends in resolution, care should be taken that the recovery is complete, for an acute inflammation may, if neglected, leave a chronic condition which is sometimes extremely hard to relieve.

Chronic Prostatitis.—Chronic inflammation of the prostate may, as has been said, follow an acute attack. It may, however, on the other hand, originate as a chronic or subacute affection.

What has been said in regard to the etiology of acute, will for the most part apply to chronic, prostatitis; but while the former is seldom the result of sexual errors alone, these are not infrequently almost wholly responsible for a chronic inflammation of the gland; and it is to be noticed that the imperfect sexual indulgence of masturbation, or partial intercourse, is much more productive of prostatic trouble than is the normal excitement of proper coition. This is probably due to the unrelieved congestion of the gland, left after these unnatural practices.

Pathology. A chronically inflamed prostate is usually somewhat enlarged, but may be natural or diminished in size. The gland is less firm than in health, and its texture is more open and spongy. Upon section the cut surface is red or dusky in hue, and moister than normal. Little points of suppuration may exist, but are usually few and small.

The mucous membrane has an increased vascularity and may be thinned, particularly if the prostatic urethra is dilated in consequence of an anterior stricture. It may, on the other hand, be thick and spongy, denuded partly of epithelium, or much roughened with spots of ulceration. Sometimes, in cases of long standing, it is pigmented. The sinus pocularis and dilated gland-ducts about it may contain pus. Sometimes an abscess-cavity exists in communication with the urethra.

Symptomatology. Patients with chronic prostatic inflammation are troubled with increased frequency of micturition, which in a mild case may be scarcely noticeable, but is often very troublesome—occurring sometimes with intervals of less than an hour.

There is usually pain of a dull, heavy character, referred to the perineum and lower rectum. There may also be considerable pain low down in the back, with twinges shooting into the thighs and testicles.

The bladder, when full, may make its condition known by a feeling of discomfort or actual pain, with intensely urgent call to urinate.

The passage of urine may be accompanied by slight scalding sensations, and there may be a twinge at the end of micturition, when the bladder shuts down upon the sensitive prostate. Occasionally tenderness in the perineum may be felt upon deep pressure.

The urine is usually cloudy and contains, more or less abundantly, clumps of muco-pus mixed with epithelial cells. These are little accumulations of secretion washed out of the dilated gland-ducts, and differ from the loose threads of mucus so common in chronic urethritis in being smaller, more coherent, and rounded in form. When the urine is passed in two portions, the first part is apt to be more cloudy and to contain these clumps of mucus more abundantly than the second part. Not infrequently, however, even when the inflammation is confined to the prostate, the pus is distributed throughout the urine and both portions are cloudy. The reason for this has been very clearly stated by Ultzmann,* and is as follows: The internal sphincter of involuntary fibres surrounding the vesical orifice of the urethra is comparatively feeble, while the compressor urethræ muscle, just in front of the prostate and surrounding the membranous urethra, is strong and competent, and being under the control of the will, it forms the voluntary sphincter of the bladder.

As discharges collect in the prostate they cannot force their way forward past the constrictor, but readily escape backward into the bladder, where they diffuse themselves through the urine. Even in these cases, however, when the urine is universally cloudy, the first portion will still be somewhat more cloudy than that which follows, and will contain many more of the mucous prostatic clumps.

The urine, when examined microscopically, will often be found to contain, besides the pus, a considerable number of blood-cells, and occasionally also a few spermatozoa. The blood may not infrequently be perceived to come at the end of micturition, when the bladder closes down upon and squeezes the congested prostate.

A chemical examination frequently shows the presence of a little albumen, often in larger quantity than the pus and blood would account for. In other respects the urine is usually normal.

If the character of the stream is noticed, it will often be found that its force is decidedly diminished, and that after the completion of urination a few drops dribble away. Sometimes partial or total retention may occur.

This interference with urination is to be partly accounted for by the swelling of the prostatic mucous membrane, but is often largely dependent on a spasmodic contraction of the constrictor urethræ muscle; and if under these circumstances a sound is passed, it will meet with decided resistance when it reaches the voluntary sphincter.

This spasmodic stricture may be so close as to greatly aggravate the difficulty and pain of micturition, for, as the bladder forces the urine into the prostatic urethra, if

* For the discussion of catheterization see under Hypertrophy of the Prostate.

* Pyuria, p. 26.

its further escape is prevented, the undue pressure in this sensitive part is productive of very great suffering. Usually the spasm of the constrictor is finally overcome by the accumulating intra-vesical pressure, and urination, beginning first by drops, presently comes with more or less freedom.

As we have said, the constrictor muscle prevents prostatic secretions from escaping anteriorly and appearing as a urethral discharge. Not infrequently, however, in these cases a glairy discharge of prostatic mucus is pressed out and escapes while the patient is at stool; especially is this the case when the bowels are constipated and much straining is required. This is commonly interpreted by the patient as an escape of semen, and he becomes convinced that he is a victim of spermatorrhœa.

Usually the microscope fails to find spermatozoa in this discharge, which consists mainly of mucus, with sometimes a little admixture of pus and blood.

Besides the local symptoms and manifestations that have been described, we see in these prostatic cases often marked changes in the general condition of our patients. They are nervous and hysterical, or may be depressed and despondent, with often a hypochondriacal over-estimate of the gravity of their trouble. Sometimes a true neurasthenic condition may be induced in a case of long standing. Digestive disturbances and palpitation of the heart may occur.

Physical Signs. An examination of the prostate through the rectum shows it sometimes slightly enlarged, but often normal or diminished in size. In consistency it is usually somewhat softer than in health.

If the urethra is explored with an instrument it is commonly very sensitive, but may be anæsthetic; the latter condition being noticed usually in old cases. The urethra should be carefully examined for a possible stricture, and it is to be remembered that the constrictor muscle will be often found to make a spasmodic contraction just behind the triangular ligament. The passage of the sound through the prostatic urethra is almost always painful, and may excite an intense desire to urinate, or an ejaculation of semen.

Diagnosis. The disease which we are considering is peculiar to young and middle-aged men, and is to be kept distinctly separate from hypertrophy of the prostate, which only occurs in the old. Inflammatory symptoms, it is true, are not uncommon in this latter affection, and will be discussed later.

Tuberculosis of the prostate offers many points of resemblance to chronic prostatitis, and a differential diagnosis is often difficult, and may be for a time impossible. The constitutional tendencies of the patient should be taken into consideration, and a careful search should be made for evidences of tuberculosis in other organs. An examination of the urine for tubercle-bacilli may help to a solution, but a failure to find them even after careful search leaves the question where it was before, for they are often sought in vain in undoubted cases of genito-urinary tuberculosis.

The discrimination between prostatitis and deep urethritis after gonorrhœa, is sometimes almost impossible. The rectal examination of the prostate may help to a decision, but not infrequently gives negative results.

A microscopical examination of the discharge obtained by pressure on the prostate through the rectum may give valuable information, but this, too, is often misleading. The discharge in either case contains pus and large and small round epithelial cells. Amyloid bodies and cylinder or caudate epithelium may be found in considerable abundance when the discharge is prostatic.

The formation of Böttcher's crystals upon the addition of a drop of a one per cent. solution of phosphate of ammonia to a drop of the secretion, shows beyond question that it contains prostatic fluid.

This reaction should be conducted on a microscope slide, under a cover-glass, and within an hour, usually, crystals such as are shown in Fig. 3113 make their appearance. They are composed of a phosphate formed from a base which exists in prostatic fluid, and which is supposed to impart to it its peculiar odor. Unfortunately, the mixture of urine with the secretion prevents the formation of these crystals, and so limits very much their diagnostic usefulness.

It is always to be borne in mind that a combination of urethritis and prostatitis is not uncommon.

Treatment should be addressed to both the general and the local condition.

The general treatment should be tonic, especially in the cases where much nervous depression exists.

A generous, unstimulating diet, with moderate exercise in the open air, and with cold sponge-baths in the morning, when the patient's strength will admit of them, are to be advised.

The laws of sexual hygiene should be carefully explained to the patient, and the importance of their observance made plain to him.

Preparations of strychnine and iron are often of benefit, and they may be advantageously combined with quinine or ergot, both of which seem to exert a soothing influence upon the prostate. Iodide of potash may be of assistance when the inflammation affects the glandular portions of the organ, and the addition of bromide of potash is sometimes distinctly useful in quieting sexual excitement.

If the urine is highly acid or otherwise irritating, its

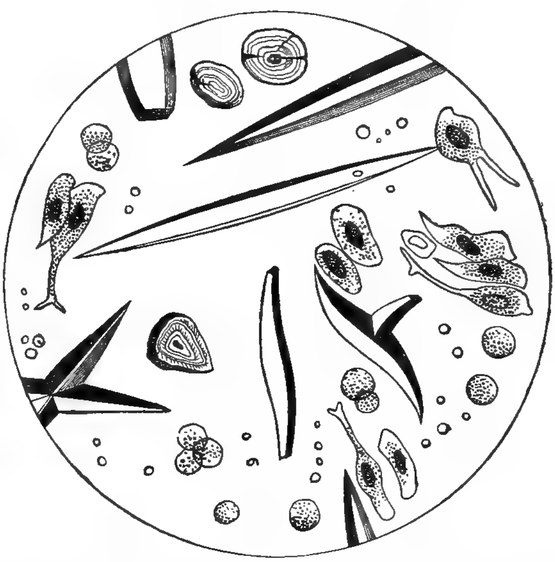

FIG. 3113.—Sediment from Prostatic Discharge, Containing Pus and Epithelial Cells, Granules, Amyloid Bodies, and Böttcher's Crystals.

character should be modified by demulcent drinks and by alkaline diuretics.

For a more direct local effect, cantharides, turpentine, sandal-wood oil, or copaiba may sometimes be administered with advantage, especially when the inflammation is mostly confined to the prostatic urethral mucous membrane.

Various local measures of treatment may be expected to contribute to the cure.

Counter-irritation to the perineum, either with tincture of iodine or with fly-blisters, is often of great use. Cantharidal collodion is a convenient blistering medium, and should be applied to a small surface close to the raphé.

Whatever counter-irritant is used, care should be taken that it does not come in contact with the scrotum or anus. After the application is dry, it is a good plan to fix a pad of absorbent cotton in the perineum with a T-bandage. This takes up the perspiration and prevents the blister from spreading to the side opposite to that where it was applied.

When there is much pain in the prostate and rectum, hot injections into the bowel may help to palliate it, and to reduce the congestion in the same manner that hot douches act upon the female pelvic organs.

FIG. 3114.—Urethral Suppositor. Consists of a hollow tube with a stylet for pushing in the suppository.

The most important local treatment, however, is that applied directly to the prostate itself, and consists in the passage of sounds, and in applications and injections into the prostatic urethra.

The use of sounds in chronic inflammation of the prostate has long been recognized as of advantage, and the benefit from them has been variously explained.

Some surgeons think that they should be used cold, and ascribe their efficiency to the astringent action of the cold. Others consider that their pressure within the prostate exerts some beneficial influence by pressing the blood out of the gland.

While some good may perhaps be attained in either or both of these ways, it is probable that the stretching of the constrictor urethræ muscle, and the consequent relief from spasmodic contraction of the same, will account, in a large measure, for the good results that follow their use. As has been said above, this sphincter is not infrequently put in a spasmodic state of contraction by the proximity of the prostatic inflammation, and in this state of stricture it has a tendency to aggravate the deep inflammation, just as an organic stricture tends to increase and perpetuate a urethritis posterior to it. It can be readily understood, therefore, that the relief of this spasmodic contraction would act favorably upon the inflammation behind it.

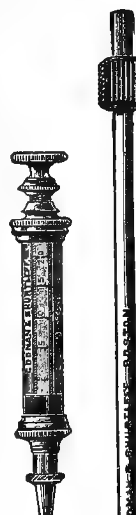

FIG. 3115.—Ultzman's Prostatic Syringe. A capillary tube and graduated syringe for the introduction of strong solutions. The curve of this and of the irrigating catheter is modified from Ultzman's instruments. See text.

As large a sound as will pass comfortably through the urethra should be used, and it should be introduced with the greatest gentleness. A sound passed roughly down through the anterior urethra will sometimes find the constrictor tightly closed against it, when, had more care been exercised the urethra would not have resented its introduction, and it would have readily passed the moderately contracted sphincter.

If the spasmodic stricture is a tight one, it will sometimes be found necessary to precede the introduction of the sound by the passage of a French, olive-pointed, conical bougie; which, insinuating its point through the obstruction, readily dilates it and prepares the way for the larger instrument.

When excessive irritability or an access of inflammation make the application of cold to the prostate desirable, it may best be accomplished by the use of the cold sound. This is a hollow instrument, which after its introduction can be chilled down by a stream of water through it. It should usually be kept in place for about five minutes.

We now come to speak of local applications to the prostatic urethra, and in these we recognize the most efficient means at our command for subduing chronic inflammation of this part.

The cases which are particularly suited to this form of treatment are those in which prostatic clumps are present in the urine, with or without a purulent secretion; in short, where the mucous membrane is distinctly affected. Medication may be conveyed to the pars prostatica urethræ either in the form of soluble bougies, by the injection of a few drops of a strong solution, or by irrigation with considerable quantities of a weak solution.

Soluble bougies are useful when it is desired to introduce an insoluble drug. They are made with gelatine or cocoa butter, in the shape of little rods about two inches in length, and are put in place with a urethral suppositor. Iodoform may be conveyed into the urethra in this way, and is often of considerable service in these cases.

The application of soluble drugs to the prostatic urethra is probably best accomplished by the injection of solutions.

The constrictor muscle, situated just before the prostate, prevents the penetration of an ordinary urethral injection, and special instruments are therefore needed for medication in the urethra posterior to it. Figs. 3115 and 3117 represent such catheters for prostatic medication.

The curve shown in these instruments has advantages both in the ease of introduction, and in the readiness with which the location of the point can be determined from the position of the handle. When the instrument is vertical* the point necessarily rests just in front of the triangular ligament; now, upon bringing it down to an angle of forty-five degrees, and at the same time advancing it slightly, the point slips through the constrictor muscle, but never passes beyond the prostate unless a special effort is made to push it on toward the bladder. Fluid injected through the catheter, when in this position, cannot pass forward through the constrictor, but washes out the prostate and escapes backward into the bladder.

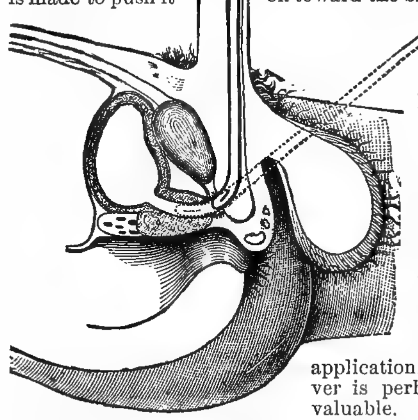

FIG. 3116.—Diagram showing that if a short-beaked instrument is held with the handle vertical, the point rests just at the triangular ligament. The dotted figure shows how the point slips through the constrictor muscle when the handle is brought to an angle of forty-five degrees with the axis of the body.

Of the various drugs used for prostatic application, nitrate of silver is perhaps the most valuable.

Two or three minims of a one to two per cent. solution should be thrown into the prostatic urethra through the capillary catheter (Fig. 3115).

Some pain of a burning character, with often considerable tenesmus, follows the application; but this usually passes off in the course of an hour or two. The injection should be repeated every four or five days, and its effect may sometimes be heightened by the previous passage of a sound. As convalescence is established, the intervals in the treatment should be gradually lengthened.

Irrigation of the prostatic urethra may often be practised with great benefit. In case there is much irritability of the neck of the bladder, with considerable muco-purulent secretion, a soothing antiseptic wash is of use. A two per cent. solution of borax or boracic acid, with the addition of a little glycerine, is a good injection for this purpose.

If the use of an astringent wash seems indicated, any of the mixtures useful in gonorrhœa may be tried. Perhaps a one per cent. solution of acetate of zinc is as good as any. The irrigating fluid, after washing out the prostate, flows back into the bladder, as has been said, and

* Throughout this article, when the manipulation of instruments is described, it is supposed that the patient is in a horizontal position.

from there it may either be withdrawn by slightly advancing the catheter, or it may be passed by the natural efforts.

After any manipulation or treatment of the prostatic urethra the patient should keep quiet, if possible recumbent, until all serious discomfort passes away, and should avoid any exposure to chill or fatigue for several hours.

Hypertrophy of the Prostate, Enlarged Prostate.—*Etiology.*—The causes of enlargement of the prostate are difficult to establish by any adequate proof.

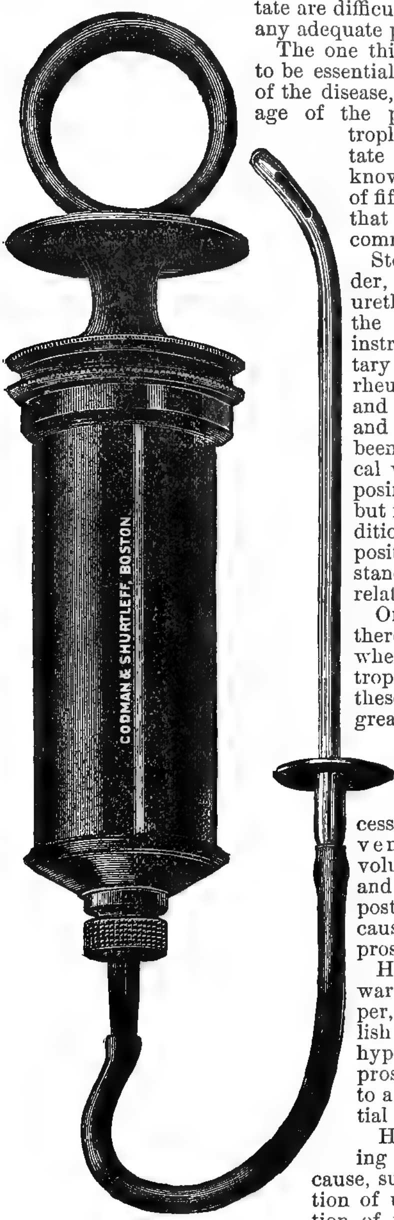

Fig. 3117.—Irrigating Catheter. (After Ultzman.)

The one thing which seems to be essential to the existence of the disease, is the advanced age of the patient. Hypertrophy of the prostate is practically unknown before the age of fifty, whereas after that it is extremely common.

Stone in the bladder, stricture of the urethra, irritation by the frequent use of instruments, sedentary habits, gouty or rheumatic diathesis, and exposure to cold and damp, have all been cited by surgical writers as predisposing circumstances; but none of these conditions has ever been positively shown to stand in a causative relation to the disease.

On the other hand, there is no doubt that, when prostatic hypertrophy exists, any of these conditions may greatly aggravate its symptoms; and besides those already named we may mention excesses in drink or in venery, prolonged voluntary retention, and the recumbent posture as familiar causes of increased prostatic congestion.

Harrison comes forward, in a recent paper, and tries to establish the position that hypertrophy of the prostate is secondary to a condition of partial retention.

He says: "Assuming that from any cause, such as long retention of urine, habit, position of the body, or the weakness connected with advancing years, the trigone, or non-contractile part of the bladder, becomes permanently depressed or altered in form, so that the person finds himself unable to get rid of the last half-ounce or so of urine, the effect will be frequently repeated efforts in all the muscles immediately adjacent to a part which, by reason of its connections and structure, has but little power of expelling.

"This will eventually lead, as I have shown, to the hypertrophy of the muscular fibres between the orifices of the ureters—the inter-uretal bar—as well as, I believe, to that of the muscular fibres so largely entering into the composition of the prostate. In this, I submit, will be found the immediate cause of prostatic hypertrophy."

It is difficult to see how, if we accept as true this theory of Mr. Harrison, we shall be able to explain the absence of prostatic hypertrophy in those cases of stricture, occurring in young or middle-aged men, where all of the expulsive muscular apparatus of the bladder is greatly hypertrophied, and still the prostate does not increase in size. This, too, at an age when the tendency to muscular hypertrophy is much greater than it is later in life. Mr. Harrison's theory also does not explain those cases of hypertrophy in which the hyperplasia affects mainly the glandular portions of the organ.

Pathology.—Hypertrophy of the prostate may occur through hyperplasia of the glandular portions of the organ, of the interstitial tissue, or of both.

As the normal size of a particular prostate can never be known, it may be hard to say, even on post-mortem examination, whether a given specimen is enlarged or not. For approximate determination, however, a prostate weighing six drachms may be regarded as normal in size, and anything over that is to be considered as hypertrophied.

Upon section of a prostate which is hypertrophied, the cut surface bulges irregularly above the capsule. It may be grayish-yellow in color or mottled with blotches of red, yellow, and gray, with occasional dark pigmented spots.

If the glandular element predominates the surface is soft, and exudes a fluid rich in cells. In interstitial hyperplasia the surface is dryer and firmer.

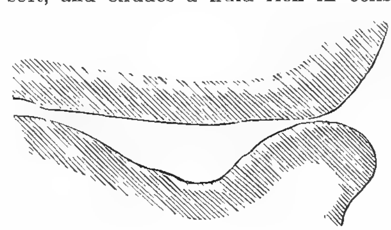
Fig. 3118.—Diagram to show the Shape of the Urethra in a Vertical Section through a Prostate with an Enlarged Middle Lobe.

Sometimes little projecting bunches announce the formation of fibrous or glandular tumors within the organ.

Usually the hypertrophy affects all parts of the gland simultaneously, but not all in the same degree.

The shape of the prostatic urethra—a matter of the first clinical and surgical importance—depends largely upon the partial or general character of the hypertrophy. If the enlargement is pretty evenly distributed throughout the organ, the urethra is in the first place considerably lengthened, sometimes measuring even seven centimetres. When the hypertrophy is partial the elongation is less, though it is still marked.

Furthermore, in cases of general hypertrophy, as the lateral lobes enlarge they compress the urethra from the sides, until it becomes a slit-like canal with tolerably firm walls in close apposition. As the lateral diameter is thus diminished, the antero-posterior diameter is correspondingly increased.

It will be readily seen that, as long as the enlargement is symmetrical, the direction of the urethra is not materially altered; but on the other hand, it is equally evident that if the hypertrophy is partial, and not evenly distributed, the unequal pressure from one side or the other of the canal will cause lateral deviations, and that, if the middle lobe is unduly enlarged, the posterior portion of the urethral floor will be raised, causing a deviation upward or toward the pubes (see Fig. 3118).

The projection upward of this lobe may make the internal urethral opening crescentic in shape, and if the middle coalesces with either of the lateral lobes this orifice is pushed over toward the opposite side.

Sometimes the middle lobe grows out into the bladder as a distinct tumor, which may be attached by a broad base, or may stand off in a pedunculated polypoid form.

Besides the changes in the prostate itself, there are

other alterations in associated organs which we must consider in connection with this disease, as they are instrumental in producing many of the symptoms which we shall have to study.

As the prostate enlarges the internal meatus is raised and a pocket is formed in the bladder just behind the enlarged gland. The bladder-wall also becomes thickened, partly in consequence of hypertrophy of the muscular coat, owing to the increased resistance against which it has to work, and partly owing to a sclerosis of the interstitial fibrous tissue, like that which has occurred in the prostate.

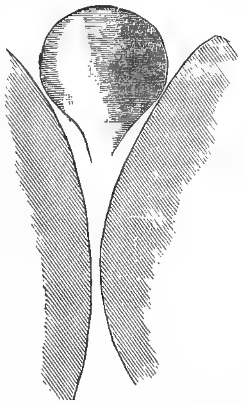

FIG. 3119.—Diagram of a Horizontal Section through the same Organ, showing how the urethra divides and goes on either side of the middle lobe.

Interlacing muscular bands often stand out from the vesical wall under these circumstances, forming trabeculæ between which there are, not infrequently, considerable pouches of mucous membrane.

The walls of the ureters and pelves of the kidneys may also be somewhat thickened, and the interstitial renal tissue undergoes frequently a hyperplasia.

As a later result of the prostatic obstruction the bladder, ureters, and pelves of the kidneys may become greatly distended.

Guyon and Lannois have laid particular stress upon the fact, already hinted at and partly understood by earlier writers, that, coincident with these changes in the urinary tract, a general sclerosis, affecting specially the walls of the blood-vessels, is going on throughout the body.

When from any cause inflammation of the bladder, ureters, or kidneys has associated itself with hypertrophy of the prostate, we have the familiar pathological appearances of cystitis, pyelitis, and pyelo-nephritis engrafted upon the organs already seriously altered by the prostatic obstruction.

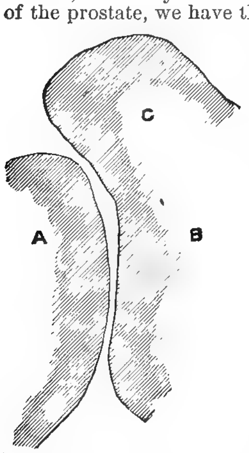

FIG. 3120.—Diagram of a Horizontal Section through a Prostate in which the right lobe, A, is moderately enlarged, the left lobe, B, somewhat less so, while the middle lobe, C, is much enlarged and is joined to the left lobe, causing a deviation of the vesical end of the urethra to the right.

For a full consideration of these complications see under Bladder and Kidneys in this HANDBOOK.

Natural History.—The progress of the disease is slow. The organs affected are not of vital importance, and the changes in them may reach a very advanced state before they seriously threaten life.

Guyon has divided the history of the disease into three periods: *First,* that of congestion, affecting mainly the prostate, but also in less degree the bladder and kidneys. *Secondly,* that of partial retention of urine. And, *thirdly,* that of distention of the bladder with usually secondary changes in the kidneys.

This somewhat empirical division gives us perhaps as good a framework as any for the classification of the clinical phenomena.

In the first stage, that of congestion, we have some enlargement of the prostate and functional disturbances, especially in the matter of urination. This condition may persist for a long time, and in certain cases, where for any reason the calibre of the urethra is not greatly interfered with, it may exist almost indefinitely without showing any tendency to pass on to the second stage, that of retention.

Usually, however, sooner or later the obstruction to the passage of the urine becomes greater than the force of the bladder can overcome, and a state of habitual partial retention is the result.

When this condition comes on slowly the accumulation of residual urine may be very insidious, and escape the observation of patient and physician alike; on the other hand, an increase in the prostatic obstruction may occur suddenly, and the unexpected complete stoppage of the urine may be the first announcement of trouble.

When the retention of the second stage of the disease develops gradually, and is not discovered and treated, the point may be finally reached where the bladder has completely lost its tone and is so distended, that the urine escapes almost constantly by an overflow (retention with incontinence). This same condition of things may follow also an acute retention which has not been relieved by catheterization and in which nature has finally established a leakage.

The third stage of the disease is now entered upon, and if nothing is done for such a case the distention of the bladder becomes extreme, and a secondary dilatation of the ureters and of the pelves of the kidneys takes place. This is soon followed by atrophy of the secreting portion of the kidney, and an increase of its interstitial tissue (interstitial nephritis).

The secondary changes in the heart and blood-vessels, usually associated with chronic nephritis, are likely to make themselves noticed at this time, if they have not already done so, and the disease becomes a constant and serious menace to life.

It is in this advanced stage of the disease that inflammatory processes, starting in the bladder, rapidly extend backward to the kidneys, and uræmic symptoms presently usher in the closing scene.

Symptomatology.—From what has been said in regard to the history and progress of the disease, it will be seen that the symptoms of the first stage are mainly dependent upon the condition of congestion in the prostate, bladder, and kidneys. And as this congestion is most considerable in the prostate, the most noticeable symptoms caused by it are disturbances of micturition and of sensation, due to the irritated state of the neck of the bladder.

In the second and third stages we have, in addition, a series of symptoms due to the mechanical obstruction to micturition, and to the changes in the bladder and other organs consequent upon this obstruction.

We shall have finally to consider the symptoms arising from various morbid conditions likely to appear as complications in the course of prostatic disease.

The first appearance of symptoms usually announces a morbid condition which has already been coming on for some time. When the enlargement takes place in such direction as not to encroach seriously on the calibre of the urethra, it may reach very considerable proportions before it causes any inconvenience to the patient.

One of the first symptoms to be noticed is an increased frequency of micturition, which is especially marked at night or early in the morning. Guyon regards this as evidence of congestion, which is aggravated during recumbency and sleep. He calls attention, also, to the frequent existence of erections in these patients, on waking, as further evidence of an increased congestion of the prostate during sleep.

Pain is ordinarily not very noticeable in the early stages of the disease, although a dull aching, or heavy dragging, sensation in the perineum, rectum, and behind the pubes is not uncommon.

If attention is paid to the manner in which urination is accomplished, it will be found that early in the disease the stream is slow to start and diminished in force. This is due largely to a loss of power in the bladder, but is to be partly explained by the swelling in the prostate, and by a spasmodic contraction and stammering action of the constrictor muscle.

The diminution in the force of the stream in a prostatic patient differs from that seen in cases of stricture,

in that, while a strictured patient can, by voluntary effort, increase the force of his stream, a man with enlarged prostate cannot do so.

Second Period. The symptoms which have their origin in congestion continue during this period, and are, indeed, intensified. Added to them we have other symptoms due to the retention, which is the characteristic condition of this stage of the disease.

The retention may be complete or incomplete.

Complete retention may be acute and appear suddenly, or it may be preceded by a period of partial retention which always develops slowly.

The symptoms which accompany a complete retention are easy of recognition, and a physical examination reveals the bladder distended above the pubes. Incomplete retention, on the other hand, comes on very insidiously, and is often overlooked for a long period, at just the time when recognition and treatment of the condition are of great importance.

Although, as has been said, partial retention comes on quietly, still a careful examination of the symptoms will usually elicit evidence of a changed condition of things, at or soon after the time when the bladder begins to fail of emptying itself. The feeling of weight behind the pubes is likely to be increased, and the frequency of micturition, which during the first stage was decidedly more pronounced at night, begins to be almost equally noticed in the daytime. The intervals between the acts of urination become short, and the call is imperative. In short, the bladder being always partly full, it takes but a small additional quantity to distend it to its full capacity.

The only positive means of determining the condition of the bladder is by a physical examination, and this should be made in every doubtful case.

Sometimes the bladder shows extraordinary tolerance, and the distention becomes so extreme as to cause incontinence from overflow, before the patient feels obliged to call upon a physician; and sometimes also, unfortunately, before the medical attendant recognizes the nature of the difficulty.

This incontinence is evidence of a very great degree of distention, and shows that the disease has entered upon its third stage. Usually, before it appears, the disease has already extended backward and has begun to affect the kidneys.

There is one symptom which may appear and give evidence that the disease has reached the third stage, before incontinence begins. This is polyuria. If the quantity of urine in the twenty-four hours is measured, it will be found to considerably exceed the normal.

Pain, which was an insignificant symptom in the first stage, may assume considerable importance in the second and third stages.

Besides the discomfort in the perineum and back due to the congested and irritated prostate, there is also considerable pain before and during micturition, caused by the distention of the bladder and its unavailing or partially successful attempts to empty itself. The passage of the urine through the prostate is also sometimes painful, and this is especially the case where the occurrence of inflammation has rendered the urine pungently alkaline and has made the parts particularly sensitive.

The examination of the urine may give negative results during the early stages of prostatic disease; but when the congestion of the kidneys is considerable there may be albumen, and even a few casts. During the last stage of the disease, when polyuria has established itself, the specific gravity is low (1.003 to 1.006) and there may be a small amount of albumen, although this is often not present. A few casts may be found at this time, too, but they are often absent even when the kidneys are extensively diseased.

In the presence of inflammatory complications the character of the urine is greatly changed, as we shall see later.

In addition to the more local symptoms which we have been considering, there are also certain general disturbances which are likely to appear in advanced prostatic disease. These are of two kinds, digestive and febrile.

Obstinate indigestion in an old man, especially if accompanied by nausea, should always lead us to take the condition of the prostate into consideration. These patients are also very liable to a low feverish condition, with extremely dry mouth and tongue, and this may announce the extension of inflammation from the bladder back into the kidneys.

We now come to the consideration of the complications which are likely to arise in prostatic cases, and of the symptoms, or variation in symptoms, to which they give rise.

They are cystitis, pyelitis (pyelo-nephritis), hæmaturia, and stone in the bladder.

Cystitis is so common in prostatic hypertrophy that it may be looked upon almost as a necessary result. It sometimes appears without apparent cause, sometimes in consequence of excesses in drink, or from exposure to cold. Far more commonly, however, it follows as a consequence of the use of the catheter or other instrument, and when it is once established it is rarely got rid of—but may, as we shall see, by appropriate treatment, be kept within very reasonable bounds.

When the inflammation of the bladder is at all acute, the pain and frequency of micturition are greatly increased. If the prostate shares in the inflammation, a great weight and bearing-down pain in the rectum may be felt, with a frequent urgent desire for defecation.

The urine becomes thick from the admixture of pus and mucus, which often settles at the bottom of the vessel in a thick, ropy mass. Presently, in the majority of cases, it undergoes alkaline fermentation, becomes ammoniacal, and has a strong pungent, often fetid, odor. The sediment now contains, besides the pus, abundant crystals of triple phosphates, often associated with finely granular amorphous phosphates.

If the inflammation extends from the bladder back through the ureters to the kidneys, the resulting pyelitis or pyelo-nephritis makes itself known by pain in the back, high fever, more or less diminution or even suppression of urine, and uræmic symptoms.

This course of things is especially liable to occur late in the disease, when neglect of catheterization has allowed the ureters to become greatly distended. Under these circumstances, any exposure to cold or instrumentation may be sufficient to start the fatal access of inflammation.

Occasionally, when the use of the catheter has been neglected after the time when it should have been begun, the final entrance upon the catheter life, instead of being a conservative measure, gives the final push toward a fatal issue. The existence of polyuria, with urine of a low specific gravity, should always lead us to fear this result.

Stone in the bladder not infrequently occurs in prostatic patients as a consequence of cystitis, in which case the stone is of the soft phosphatic variety; or a stone composed of uric acid, oxalate of lime, or cystin may form, and owe its origin primarily to a constitutional condition.

In either case the prostatic hypertrophy may be regarded as partly responsible for the formation of the calculus.

In the first case, of the phosphatic stone, the obstruction, by causing the cystitis and fermentation of the urine, stands in a pretty close causative relation to the calculus. In the second case, in which the deposit of crystals from the urine is due to a constitutional tendency, the obstruction at the prostate may be the condition which decides whether a stone shall form or not. For, when the bladder is completely emptied at each urination, the crystals as they form are thrown out and do no harm, whereas when a pocket has been formed behind the prostate in which there is always residual urine, the sand collects there and soon agglomerates itself into a concretion.

When a stone forms behind an enlarged prostate the pain is usually much increased, and is less amenable to treatment. It is referred often to the glans penis, and is

greatly aggravated by motion, especially by riding in a jolting vehicle. It is commonly less marked at night or during rest.

Hæmaturia in case of stone is very likely to appear after exercise or riding, while prostatic hæmorrhage from congestion seems to be independent of any jarring of the bladder—in fact, is rather more likely to come at night, when recumbency favors prostatic congestion.

The sudden stoppage of the stream in the midst of urination, by the rolling of the stone against the opening of the urethra, is less likely to occur in case of an enlarged prostate than in a healthy bladder, owing to the lodgement of the stone behind the prostate, below the urethral orifice.

If the presence of the stone affects the frequency of micturition, it tends to increase it rather in the daytime, when motion causes the stone to move about, than at night, when it is at rest.

Hæmaturia, as has been said, may result from the congestion of the prostate or from the presence of a stone. We may also have hæmorrhage of considerable amount and duration, following the use of instruments; and, lastly, the too sudden emptying of an over-distended bladder may lead to an attack of hæmaturia, from the capillary oozing from the vesical wall.

Sometimes clots of large size may form in the bladder, and cause much pain and discomfort before they are broken up and expelled.

Physical Examination.—Having decided from the symptoms that there is a probability that prostatic hypertrophy exists, a thorough examination should be made of the prostate and bladder.

The objects of this investigation are, to ascertain the stage at which the disease has arrived, to learn the amount of obstruction and the configuration of the prostatic urethra, and to discover any complicating conditions which may exist.

The patient should first empty the bladder, so far as possible by the natural efforts, and the hypogastrium should then be explored by palpation and percussion, to see whether enough distention of the bladder remains to be detected in this region. The normal variations in the position of the bladder and intestines render this examination often unsatisfactory, especially when the abdominal wall is thick or rigid.

The examiner should then explore with the forefinger the rectum. This is best done with the patient on the back.

If the prostate is enlarged it will be felt pressing down the anterior rectal wall. Its size, shape, and consistency should be noticed.

The relative enlargement of the lateral lobes can usually be well made out, and nodular projections are sometimes felt, caused by irregularities in the hypertrophy of different parts of the gland. Rectal examination, unfortunately, gives little or no information in regard to the condition of the third lobe, which is so often the cause of a serious obstruction to the flow of urine.

Incidentally the degree of tenderness to palpation will be discovered.

The condition of the prostate itself having been determined, the examining finger should be carried up along the posterior vesical wall, if that be possible, and the condition of the bladder should be learned. In this investigation the bi-manual manipulation between the finger in the rectum and the hand above the pubes, so commonly practised in examinations of the female pelvic organs, is useful, and by it the amount of distention of the bladder can often be most accurately made out.

Lastly, the urethra and bladder should be explored.

The existence of a stricture will probably be detected in the passage of instruments for deeper exploration. But in case of doubt the canal may be thoroughly examined with large bulbs. A short-beaked sound should be passed, and as it runs through the prostate deviations of the urethra will often be shown, by the feeling of resistance on one side or the other and by the turning of the handle.

The sound in entering the bladder may sometimes be felt to slip up over a bar, or may turn to one side around a prominent third lobe.

After a proper search has been made for a possible stone, the sound should be depressed until it lies in the axis of the body, and then withdrawn until the concave side of the beak comes against the neck of the bladder; it may then be rotated, and, as the beak sweeps the vesical face of the prostate, any irregular outgrowths or projections will be felt to arrest its movements.

If the sound has been felt to ride over an obstruction at the neck of the bladder and, after it is in, rotates firmly, this points to a bar rather than to a globular enlargement of the third lobe, which last would arrest the beak of the sound in rotation.

As the instrument is withdrawn slowly through the prostate, the deviations due to projections into the urethra are often felt even more plainly than during introduction.

Finally, the urine may be withdrawn with a catheter and the exact amount of residuum thus discovered. This will be found to vary much at different times, and depends somewhat upon the amount of urine which the bladder contained before the last urination.

When the bladder is full and the urine consequently rushes out with some force in a considerable stream, it will often be found that there is much less water left in the bladder than is the case when urination has been attempted before complete distention has been reached.

Diagnosis.—The conditions with which enlarged prostate is likely to be confounded are stricture of the urethra, stone in the bladder, cystitis, cancer or other tumor of the prostate, tuberculosis of the prostate, and tumor of the bladder.

The physical examination, if thoroughly made, usually enables us to eliminate the first two of these conditions, and if enlargement of the prostate with residual urine is found we may, in the absence of other discoverable cause, decide an existing cystitis to be dependent upon the prostatic trouble.

The decision between a tumor of the prostate and simple enlargement is extremely difficult, unless the tumor has assumed considerable proportions or has begun to invade surrounding parts. The physical examination by the rectum gives us our best help in diagnosis, but the irregular growth of a tumor may at first simulate the irregularities sometimes seen in hypertrophy.

The pain attendant upon the growth of a tumor is more severe than that appearing early in hypertrophy, though this is by no means constant.

In case of a cancer the enlargement of neighboring glands may help us to the right solution of the question. Not infrequently, however, it will be necessary to wait until the progressive growth of the tumor declares its character.

Tuberculosis of the prostate usually occurs earlier in life than we could look for hypertrophy. In case of doubt, tuberculous deposits must be sought for in other organs (epididymis, seminal vesicles, lungs, etc.).

A tumor of the bladder may give rise to hæmorrhages and difficulties of micturition which simulate those caused by enlargement of the prostate. Also a tumor may be present in the bladder behind an enlarged prostate, and so complicate the symptoms.

The hæmorrhage from a tumor is ordinarily very much greater than that from a congested prostate. But this is not always the case, and whenever there is persistent or intermittent hæmaturia, however slight, a careful search should be made for villi or other bits of the tumor which may be detached and passed in the urine, and which may be recognized under the microscope.

Examination of the bladder with the sound may, when a tumor is there, reveal a projection somewhere from its wall. But sensations of this sort are very misleading, and it is well, after a thorough sounding, to wash out the bladder with the litholapaxy evacuator, with the object of obtaining bits of the tumor, if one is there.

After definitely settling the diagnosis of prostatic hypertrophy, it is always important to go further, and to decide in what stage the disease is, as we shall see that the treatment should vary according to the varying conditions.

The steps to this decision have been sufficiently indicated above.

Treatment.—As has been described, the disease under consideration consists essentially in a tendency to congestion of the prostate, bladder, and kidneys, with an accompanying hypertrophy and sclerosis.

For convenience we have divided it into three stages: first, of congestion, with functional disturbances; second, of simple retention; and, third, of retention with distention, often incontinence, and perhaps involvement of the kidneys.

First we will consider those measures of treatment, hygienic and medical, which are applicable to all stages of the disease.

Anything which has a tendency to increase the congestion, should be carefully avoided. A chill of the surface should be especially guarded against. The patient should wear flannels next the skin, and should carefully avoid draughts or long exposure to chilly and damp air.

The feet should be kept dry and warm, and if the patient gets up at night to pass water, use the catheter, or for other purpose, he should cover his feet and legs warmly. Neglect of these precautions may at any time bring on an attack of retention, cystitis, or even of pyelo-nephritis.

Excesses in eating and drinking are to be avoided. Large quantities of rich or highly seasoned food must not be indulged in, and wine or beer are for the most part better left alone. This caution should be understood to apply only to overeating, as a sufficient quantity of nourishing food is of importance. If the patient has been in the habit of taking a stimulant, a little light claret, or some whiskey and water, may be allowed with meals.

Especial warning should be given against holding the water over the ordinary time, particularly if any call to pass it is felt. An attack of complete retention or of cystitis may result from disregard of this rule.

Venereal excesses are, of course, to be avoided.

The effect of sedentary habits and of horizontal decubitus in increasing the passive congestion, must be borne in mind, and moderate gentle exercise is to be advised. The patient will do well, when engaged in any occupation that keeps him long in one position, to take an occasional turn through the room; and at night or in the morning, when up for the purpose of emptying his bladder, a short walk about his chamber will often materially assist him in making his urination thorough and satisfactory.

Constipation should be carefully guarded against. In prescribing for this condition, the violently acting drugs, which produce more or less congestion of the pelvic organs, should not be used.

The greatest assistance will often be obtained from rectal injections. These are especially useful when the mechanical obstruction of the prostate, pressing upon the rectum, is largely responsible for the failure of the bowels to act.

Cold injections are usually to be avoided, though they may sometimes render good service in helping to restore the functions of an atonic bladder. Hot injections (112° to 115° F.) will sometimes assist in reducing congestion.

The functions of the skin should be stimulated as far as possible. Rubbing and massage are to be employed to this end, and baths also serve a useful purpose if care is taken against a subsequent chill. A hot bath ending with a sponge off in cold water, and vigorous friction with a rough towel, may be of real benefit, by bringing the blood to the skin and so relieving internal congestion.

In selecting a climate for a prostatic patient, preference should be given to dry inland localities, where sudden changes of temperature are less likely to occur than on the sea-coast. Sometimes, however, when the general condition is depressed and a stimulating climate is desirable, the sea-side may be tried, special precautions being taken against surface chills.

General medication directed against the disease itself has but little to offer.

The iodides may have a trial, in virtue of their reputation in the treatment of sclerotic conditions of the blood-vessels and other organs. If used they should be persisted in for a long time, with occasional intermissions. They have the disadvantage of sometimes disagreeing with the stomach, and it may be necessary to discontinue them on this account.

Of the medication required in the various morbid conditions which may from time to time need correction, we shall speak in considering the treatment of the various periods.

Treatment in the First Period is almost wholly hygienic and medical.

In the absence of complications, and before there is any retention, the less instrumentation the better, as it only aggravates the congestion, and introduces the danger of infection from dirty instruments.

If the urine is irritating from too great acidity, an alkaline diuretic, such as citrate or acetate of potash, is indicated.

In case of pain, belladonna or hyoscyamus should be administered either by the mouth or by the rectum. Opiates should be avoided, if possible, as they derange the stomach and constipate the bowels. When urgently required, however, they may occasionally be resorted to.

Ergot, strychnia, or nux vomica in some form, and quinine, are sometimes useful, and act apparently by diminishing the congestion, and perhaps also by stimulating the contractions of the bladder. If the circulation is not good, cardiac stimulants may be of assistance.

Second Period. When the stage of partial retention has set in and the patient passes water, but is not able to completely empty the bladder, it is necessary to resort to the use of the catheter. So important is this, that every patient who is seen in the first stage and put upon general treatment, should be warned that the time will almost certainly come when catheterization will be required, and that as there is no sure means by which he can tell when he reaches this state, he should occasionally present himself for examination to decide this point.

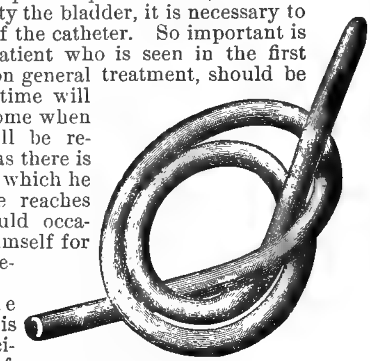

Fig. 3121.—Soft-rubber Catheter.

Sometimes the partial retention is due to some accidental increase of congestion, which may disappear under the use of antiphlogistics. In such a case the patient may be put to bed with leeches to the perineum, followed by hot applications assisted by opiates, if necessary.

If these measures fail, it will be necessary to draw the water, and it will sometimes be found that, after a short systematic use of the catheter, the bladder will recover itself and again become able to fully expel its contents. Thus the disease may occasionally be moved back from the second period into the first.

When complete retention comes on suddenly the catheter is indispensable, but in this case again its use may perhaps later be given up.

When entering upon the use of the catheter, we may often learn whether it is really needed by noticing the effect upon the symptoms. If these are relieved or ameliorated, we are evidently on the right track.

It is to be remembered, however, that not infrequently, on commencing catheterization, a cystitis develops itself, owing either to the too sudden evacuation of a distended bladder, to the introduction of dirt upon the catheter, or simply to the irritation from the constant use of instruments. It is important that the aggravation of symptoms caused by this inflammatory onset shall not lead the patient or doctor to infer that the catheter is doing harm and should be given up, for it is by continuing its use that the attack of cystitis may be most quickly and surely relieved.

Let us now consider how and with what instruments the catheterization is to be carried out.

As has been described, the walls of the urethra are pressed together and may be somewhat deviated by the inequalities of the lateral lobes. The posterior part of the urethral floor is also often raised by the projection of the third lobe.

Our object is to reach the bladder through this sinuous passage with the least possible amount of irritation.

FIG. 3122.—Elbowed Catheter (Sonde Coudée of Mercier).

If a soft, red rubber catheter will find its way into the bladder, it is, by all odds, the best instrument to use. It requires no skill for its direction, and can do no damage to the urethral walls—a point of great importance, as it enables us to entrust its use to an unskilful patient.

When, owing to the narrowness or tortuousness of the urethra, the rubber catheter will not pass, we must resort to a stiffer instrument, and must adapt its form in reference to the difficulties which it has to overcome.

The obstructions which it will meet project from the lateral walls and floor of the canal, and our effort must

FIG. 3123.—Double Elbowed Catheter (Sonde Bicoudée).

be to carry the point of the instrument along the upper or anterior wall.

Mercier devised for this purpose a flexible webbing catheter with the point sharply turned up (sonde coudée), so that it might ride over the obstructions on the floor.

For those cases in which the hypertrophy of the third lobe was very pronounced, he used a catheter with a second bend, designed to lift its point still higher.

In introducing these instruments, care should be taken that the point be kept turned toward the roof of the canal, and after it has passed the triangular ligament the penis should be depressed as much as possible between the thighs, so that the catheter may be pushed straight upward in the axis of the body.

The English gum-elastic catheter may often be used with advantage, either with or without its wire stylet. If introduced without a stylet it is a good plan to exaggerate the curve of the instrument, as has been suggested by Thompson. When used thus it should be introduced cold and carried as rapidly as possible through the anterior urethra, for as it warms it becomes flexible and loses its form. By passing it rapidly but carefully, its curve often carries it over the obstructing third lobe.

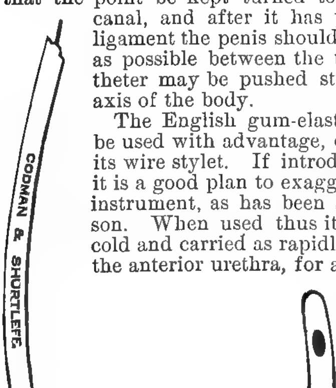

FIG. 3124.—English Gum-elastic Catheter with Exaggerated Curve on Stylet. (After Thompson.)

If it meets an obstruction and, warming in the urethra, becomes flexible, the forefinger in the rectum should be used to lift the point of the catheter into the prostate, while at the same time the handle should be brought down to the axis of the body, and the instrument, which is then practically straight, should be pushed steadily into the bladder. This should be done without the exercise of much force, as the point, when properly guided, slips along quite easily and when it catches there is danger of its making a false passage if pushed.

If the gum-elastic catheter is introduced with a stylet it should be curved into the form of a prostatic silver catheter. Sometimes, when the point catches it may be lifted over the obstruction by the simple manœuvre of slowly withdrawing the wire while slightly advancing the instrument. This curls the point upward and often enables it to ride over the obstacle.

Occasionally, when other flexible instruments fail, the French conical bougie catheter will succeed in worming its way through the canal. It should be used with great caution, as its comparatively sharp point may catch in and perforate the mucous membrane.

Failing with other instruments, we may have recourse to a metallic catheter of large curve.

The beak of this instrument should be long enough to reach easily through the enlarged prostate, which may be one inch and a half longer than in the normal state. If the curve is too short the point does not reach the bladder, but being engaged in the prostate, runs considerable risk of making a false passage when the handle of the instrument is depressed.

The forefinger in the rectum may give great assistance in guiding the passage of this catheter.

In using any instrument in a urethra with false passages it is a good plan to always withdraw for a considerable distance when the point is caught, and then to try and pass the pocket by carrying the beak down first one wall and then another until the right passage is found. Ordinarily the false passages exist in the floor of the urethra; but this rule has many exceptions.

If, in a case of complete retention, after careful and thorough attempts we do not succeed in reaching the bladder, recourse must be had to puncture with trocar or aspirating needle.

This was formerly done through the rectum with curved trocar, but as this method cannot be used antiseptically the supra-pubic puncture is to be preferred. This may be done with a fine needle introduced close above the pubes, and, if necessary, may be repeated two or three times daily for a considerable time. Usually, however, drawing off the urine in this way is followed by such a subsidence of the swelling as to presently allow the introduction of the catheter. Leeching the perineum and the administration of ergot may also be of service in reducing the congestion.

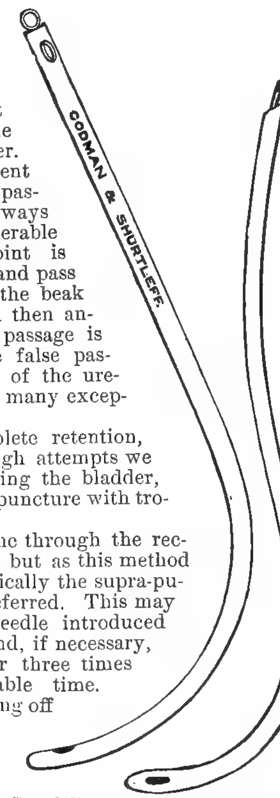

FIG. 3125.—Silver Catheters of Curve Appropriate for Use through an Enlarged Prostate.

The evacuation of a distended bladder, whether by catheter or by aspiration, should be performed slowly and carefully. When the distention is extreme, the bladder should not be wholly emptied at one time, for if the internal pressure is too suddenly relieved we are likely to have a great congestion of the vesical mucous membrane, with the escape of blood into the urine, followed often by considerable inflammation.

The greatest care should likewise be taken in the matter of thorough antiseptic cleanliness, as the introduction of germs into the bladder may start a fermentation of the urine with cystitis. It is of course important, whenever a catheter is entrusted to a patient, that careful instructions should be given to him in regard to this.

Catheterization having been commenced, how often should it be repeated?

In the cases of partial retention with moderate residu-

um, the use of the catheter each night before retiring is usually sufficient. As the disease progresses, however, a point is presently reached when the bladder habitually holds from six to eight ounces of residual urine, and the calls to urinate are consequently pretty frequent. Under these circumstances the regular use of the catheter is required.

If now the patient can get along comfortably while using the catheter four times a day, he is fortunate, and may live for twenty or more years with this artificial urination. Not infrequently catheterization will be required six, seven, or even more times in the twenty-four hours. Especially is this the case when cystitis is present. The water should always be drawn when the desire to micturate is urgent and persistent.

When catheterization is required so often as to become a decided source of irritation, and if the bladder is so irritable as to be constantly liable to painful contractions, it will be found best to tie in the catheter for a time (sonde à demeure). Usually in a few days, after the bladder has had a rest, the catheter can be again left out and the patient can resume regular catheterization.

Treatment of the Third Period. In this stage of the disease, systematic emptying of the bladder is as urgently called for as at any earlier time. The serious changes, however, which are likely to have occurred in the ureters and kidneys, with the condition of passive congestion which exists throughout the urinary tract, make the use of the catheter a matter of considerable danger, which, in some cases, may be so great that it will be better practice to leave the bladder undisturbed.

In these cases the patient's condition of comparative health—troubled, it is true, by frequent and often partly involuntary micturition, but not debarred from ordinary occupations—makes a striking contrast with the state of things which may rapidly develop upon entering on the "catheter life." For a slight added irritation to the bladder may be suddenly followed by a pyelo-nephritis, or even more abruptly by renal congestion with suppression, uræmia, and death.

These dangers are alarming and imminent enough to make us hesitate, but what is to be hoped from allowing the disease to take its course? Nothing but a certainly fatal issue, which is likely to come in a few weeks or months, and which may be precipitated at any time by an exposure to cold, by fatigue, or by a slight indiscretion in diet.

On the other hand, when catheterization is successfully established, the disease may be moved back from the third to the second stage, and the patient who was in such danger may be put in a state of comparative security.

It is, then, of the first importance to distinguish the cases in which catheterization is so dangerous that the patient had better be left to follow out the natural course of the disease; and in all except these most advanced cases the catheter should be used.

Each case must be decided on its merits, and so much depends on attention to detail, that we should sometimes be deterred from commencing catheterization with a careless and slovenly patient, when we should have resorted to it could we have counted on his intelligent co-operation.

Guyon has laid down a rule of practice for these advanced prostatic cases, which is a good one.

He puts the patient upon general tonic treatment, and if he finds that he is wanting in strength sufficient to benefit by it, he does not regard him as in a state likely to be helped by interference with his bladder. If, however, he improves decidedly in his general condition, then Guyon regards it as wise to resort to the catheter.

The precautions to be observed in accustoming the patient to the catheter are the same that are required in the second stage of the disease, but they are now even much more important.

Especially should the sudden emptying of a distended bladder be guarded against. It may often require two or three weeks of catheterization before the bladder acquires such tolerance that it may safely be left empty.

During the preliminary period the catheter should always be passed with the patient horizontal, to guard against the too rapid flow of water; afterward, when the complete emptying of the bladder is desired, the vertical position is the best for this operation.

Treatment of Complications. Cystitis, which is the most common complication of prostatic hypertrophy, is to be treated according to the rules laid down under Diseases of the Bladder, on pages 514 and 515, in vol. i. of this HANDBOOK.

When it occurs in the first stage of the disease, general treatment is to be first thoroughly tried, and local treatment through a catheter is to be resorted to only when simpler measures fail. In the second and third stages, when partial retention exists, the systematic evacuation and irrigation of the bladder is the most efficient means of treatment at our command.

FIG. 3126.—Mercier's Prostatome, with Cutting-blade, L, and Set-screw, V, V.

Nephritis, or pyelo-nephritis, must be treated on general principles. Mustard poultices over the lower dorsal and lumbar regions during the acute stage, with, afterward, careful rubbing and friction to keep up the action of the skin; a bland, non-stimulating, but nutritious diet in abundant quantity, and regulation of the bowels. If uræmia threatens, pilocarpin and hot-air baths may be used to promote elimination, and to relieve the congestion of the kidneys.

A stone in the bladder can usually be removed readily by litholapaxy through an enlarged prostate, unless it is of great size and hardness, or unless the careless use of instruments has produced false passages. The pocket behind the prostate often holds a small stone concealed, and makes it hard to seize, in which case the hips may be raised so that the stone rolls back toward the fundus, where it is easily found and crushed.

When micturition is very difficult, it may sometimes be thought wise to remove small stones by perineal incision, in the hope of, at the same time, relieving the obstruction.

When litholapaxy is impossible on account of the size and hardness of the stone, it is usually necessary to resort to the supra-pubic incision. By this operation, too, a prominent middle lobe, or other cause of obstruction, may sometimes be removed.

RADICAL OPERATIVE TREATMENT.—Finally, we have to speak of the various operations which have been devised for the relief of obstruction in the prostate. These may be divided into the internal and external operations.

The internal operations are mainly useful in the treatment of those cases in which the obstruction assumes the form of a bar, and are not so applicable to cases of greatly hypertrophied and projecting third lobe. They may consist in simple incision, or in excision, of a portion of the obstructing part.

Mercier, who was a strong advocate of these operations, devised two instruments for their performance.

One, for making a simple incision, is shaped like a short-beaked sound, and carries a concealed knife which can be made to cut upon either the concave or convex side of the beak. The bar can, therefore, be divided by hooking the beak of the instrument over it, and then, by withdrawing the blade, making an incision, the length of which can be exactly regulated by a set-screw in the handle.

An incision can also be made from before backward by placing the heel of the beak in front of the obstruction with the point upward, then making the blade pro-

trude on the convex side and advancing the instrument into the bladder.

When the bar is of considerable width or forms much of a projection, Mercier uses another instrument somewhat like a lithotrite. The obstruction is engaged between the blades of this, and as the instrument is closed it punches out the part included. If enough is not removed the first time the operation is repeated.

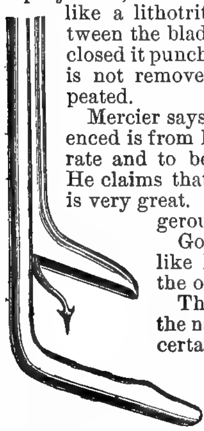

Fig. 3127.—Blades of Mercier's Instrument for Punching out a Piece of the Obstruction.

Mercier says that the only difficulty ever experienced is from hæmorrhage, which is usually moderate and to be overcome by appropriate means. He claims that the relief following the operation is very great. Other operators have reported dangerous hæmorrhages.

Gouley has also an instrument not unlike Mercier's, and he claims priority in the operation.

The necessity for an exact diagnosis of the nature of the obstruction, and the uncertainty in the thorough performance of the operation, limit very much its usefulness.

The perineal operation consists in a median incision down into the membranous urethra. Through this opening the finger is passed along the prostatic urethra, and under its guidance a probe-pointed knife is introduced and a section made through the obstruction. A good-sized tube is then fastened into the bladder through this opening. This tube by its pressure checks hæmorrhage, provides dependent drainage, and, by holding the wounded surfaces apart, moulds the urethra during healing.

The prostatic urethra admits of such dilatation that, if a polypoid projection is found it can be removed with a small tonsillitome or wire noose.

This operation, which owes its present prominence to Mr. Harrison, is a very useful one, and has the great advantage of giving thorough drainage and a long rest to the bladder. The relief to the obstruction is often, if not usually, very satisfactory.

The tube should be kept in place for a number of weeks or even months, and before it is finally left out, the patency of the canal should be tested. Usually the first indication that it may safely be removed is the appearance of urine along the urethra.

As has been stated above, the prostate may be reached and operated on by the supra-pubic incision. This method, however, introduces special dangers and has no advantage over the perineal operation, except in cases complicated by obscure bladder lesions.

Atrophy of the prostate may occur as the result of mechanical pressure, or of destruction of portions of the organ by inflammation. It may also appear in the course of an exhausting disease, or as a consequence of old age. It gives rise to no symptoms and calls for no treatment.

Tumors of the Prostate.—These may be classified as follows:

Cysts	Retention Cysts. Hydatids.
Myoma Adenoma	Adeno-myoma.
Sarcoma	Round cell. Spindle cell. Lympho-.
Carcinoma	Scirrhus. Colloid.

Retention cysts formed from dilated gland acini occur in many old prostates. They are always small, and give rise to no inconvenience. Their contents are sometimes inspissated, forming little concretions.

Hydatid cysts of the prostate are so rare that Thompson could, in 1883, learn of but one; and even in that case it is doubtful whether the cyst started in the prostate or near it. When discovered they should be at once emptied.

Pure myoma is very rare; adenoma is somewhat less so, but adeno-myoma is the most common of prostatic growths. Paul thinks ordinary hypertrophy should be ranked under this head.

The universal, symmetrical enlargement can hardly, as it seems, be classified as a tumor, and yet the pathological process is the same in it and in the circumscribed masses which we recognize as new-growths. These may project into the urethra, the bladder, and in other directions, or they may be buried in the midst of the gland-tissue, from which they can be easily shelled out.

These tumors have sometimes been removed during section of the gland in lithotomy or other operations, and the removal of projections into the urethra has been considered above.

Sarcoma is occasionally observed in the prostate, where it may start primarily, or to which it may transplant itself from the testicle or elsewhere. It usually appears early, but may develop late in life.

Carcinoma is still less common than sarcoma, and appears ordinarily after middle life. It may assume a scirrhus or a colloid type.

In either of these last two malignant forms of growth there may be a good deal of pain and considerable hæmorrhages, especially after instrumentation.

In carcinoma the neighboring lymphatic glands are likely to be early involved.

Any cyst or tumor of the prostate may give rise to symptoms of obstruction. The difficulty of micturition may reach a point to require some operation for its relief. In opening the bladder for drainage under these circumstances, either the perineal or the supra-pubic incision may be used, and the selection would depend somewhat upon the size of the tumor.

If this is large and of a malignant character which makes its removal evidently impossible, supra-pubic drainage would be preferable.

On the other hand, in the case of a smaller or non-malignant tumor the perineal incision should be used, as by it the exact condition of things can be ascertained and possibly benefited. Harrison reports a case in which he removed a cancerous growth as large as the last phalanx of the thumb from the prostatic urethra. The operation was followed by great relief from distress in micturition, and the patient lived for fourteen months.

Tuberculosis of the Prostate occurs often secondarily to tubercular conditions in other parts of the genito-urinary tract. It probably also appears sometimes primarily in the prostate.

As patients with genito-urinary tuberculosis usually die when the disease is far advanced, it is rarely possible to decide at autopsy where the disease originated, and as the organs are many of them deep-seated and beyond the reach of physical examination, it is likewise impossible during life to be sure that the prostate was primarily affected.

On the other hand, this gland is situated at the junction of the genital and urinary passages, is as it were at the cross-roads through which any tuberculous material from the kidneys or testicles must go in its passage from the body. This situation makes it peculiarly liable to secondary infection, and, as a fact, it is almost always sooner or later involved.

The tubercles may appear as little isolated gray granules, scattered throughout the tissue of the organ, or they may be agglomerated into masses which, if they reach a moderate size, ordinarily become cheesy in the centre and finally break down into abscesses.

Sometimes almost the whole prostate is thus destroyed, and its place is occupied by an abscess which usually communicates with the urethra and bladder. It may break through into the rectum, forming a recto-vesical or urethral fistula directly through the prostate.

The *Symptoms* are those of a chronic prostatitis (see above) with a special tendency to hæmorrhage. They may be associated with evidences of tuberculosis elsewhere.

Physical Examination by the rectum may reveal little or no alteration in the gland. Ordinarily, however, inequalities are felt which may give it a distinctly

nodular character. This may be associated with enlargement, or the prostate may preserve almost its normal size.

The ejaculatory ducts and the vesiculæ seminales should be felt for, and if the disease has affected them, they may be found as thickened, resistant, cord-like bodies. This is especially to be observed when the disease started in the testicle and worked its way up to the prostate.

Not infrequently a little shot-like mass is felt between the rectum and the prostate, or it may be a little behind and to one side of the gland. It is not attached to the prostate, rectal wall, or seminal vesicles, but is loose in the tissues between them.

Dr. Bryson, of St. Louis, thought that in one case, in which he had an autopsy, he made it out to be a cheesy mass within a vein. Possibly it is sometimes an infected lymphatic gland.

The testicles, epididymes, and vasa deferentia should also be examined, and the urine should be investigated for evidences of kidney complication and for tubercle-bacilli.

These last are very difficult of detection in the urine, and their apparent absence does not argue against tuberculosis. When unmistakably present they are conclusive confirmatory evidence.

The physical investigation should also include the examination of the lungs, which may share in the tuberculous process.

Diagnosis.—The disease may be confounded with chronic prostatitis or cystitis, with stone or tumor in the bladder, or with pyelitis when accompanied by frequent micturition.

While a careful consideration of the symptoms and inherited tendencies of the patient may enable us to form a probably correct idea of the condition, it is only by a careful physical examination that we can reach a positive diagnosis.

Besides the examination described above, an exploration of the bladder, under ether if necessary, will be needed for the detection or elimination of stone and of tumor of the bladder.

There will be a certain number of cases in which a diagnosis is at first impossible, and in which the true interpretation of the condition can be reached only when time has developed characteristic symptoms.

Treatment.—Most important is the constitutional treatment with cod-liver oil, hypophosphites, and iodides. A healthy out-of-door life, with moderate exercise and good food, are to be enjoined.

Thompson advises against local treatment, and it is certainly important to avoid rough manipulation.

In the early stages of the disease, however, gentle local measures may serve rather to allay than to excite irritation, and should be tried.

Irrigation of the prostate and bladder, and the introduction of iodoform pencils, may be of service. Occasionally the passage of a sound is useful by removing the contraction of the constrictor muscle. The pain and frequency of micturition may sometimes be much relieved by these means.

While the prognosis is necessarily grave, and the permanence of improvement is always doubtful, still these cases are not always hopeless if seen early.

PROSTATIC CALCULI.—In the ducts and dilated tubules of the prostatic glands are found not infrequently little yellowish or brownish bodies, composed of an organic substance allied to protein.

These, if they increase beyond a moderate size, begin to have earthy salts deposited in and around them, and finally become prostatic calculi, which may reach the size of a walnut, or even larger.

These calculi are usually multiple, and are facetted from mutual attrition. They are hard, take a high polish like porcelain, and are white or light-brown in color.

Chemically, they are composed almost wholly of phosphate, with a slight admixture of carbonate, of lime, and are to be distinguished from urinary calculi by the fact that they do not contain any of the triple phosphate of magnesia and lime, which is so large a constituent of vesical calculi.

When prostatic calculi are made out they may be removed by a median or lateral perineal incision. The operation is usually one of no serious danger, as the bladder is not opened.

Arthur T. Cabot.

PROTOPLASM. Wherever in nature that group of phenomena which we call vital is manifested, we find it invariably associated, whether in higher or lower beings, in animals or plants, with a particular form of matter which is called *protoplasm*. Protoplasm is living matter.

The exact chemical constitution of protoplasm is unknown; but its proximate analysis, after being deprived of its vitality, shows that in this dead condition it contains proteids, carbohydrates, fats, certain inorganic salts, and water.

Physically, as seen with high powers of the microscope, protoplasm appears to be nearly homogeneous, or to consist of a structureless, semifluid material in which are suspended granules and minute fibrils.

In the higher, and in most of the lower animals and plants, protoplasm exists in the form of tiny lumps of various shapes and sizes, which are called *cells*. For a detailed description of these cells, and the life-characters which they display, consult the article on Cells.

While the phenomena of life are never manifested except in connection with this particular form of matter called protoplasm, whether in animals or plants, we should not be led by the apparent simplicity and comprehensiveness of the statement into a belief that we know very much about its real nature. "Life is a property of a certain kind of compound matter." To this matter we give the general name protoplasm. But it should not be inferred from this that protoplasm is everywhere identical in its constitution. On the contrary, it would seem that it must be actually as varied as are the manifestations of life which we observe in the different forms of cells, although this variation is not evident by any chemical or physical means of analysis at present known.

The term protoplasm is sometimes used in a purely anatomical sense, to signify that part of the cell which immediately surrounds the nucleus, and which is more properly called the cell-body.

Parts of certain cells, as the membranes of some forms, or the entire body, as in epidermic scales and some of the cells of the hair-shaft, may become converted into a dense material, which, though contributing to cell-structure, does not exhibit the phenomena of life and is often called, though the expression is not a proper one, dead protoplasm.

T. Mitchell Prudden.

PRUNE (*Prunus*, U. S. Ph.; *Prunum*, Br. Ph.; *Prunier commun*, Codex Med.). The fruit of the garden Plum, *Prunus domestica* Linn., order *Rosaceæ*, dried in the sun or by artificial heat. This well-known fruit-tree is said in Bentley and Trimens' "Medicinal Plants," to be probably descended from *P. insititia* Linn., a thorny shrub with pubescent twigs and spherical fruits (purple-black, yellow, or green), growing wild in the mountains of Western Asia, Greece, etc., and also cultivated. The common Plum-tree has no thorns, but smooth branches and an oval fruit, of blue-black or yellow color, covered with a thin layer of waxy "bloom." The varieties are numerous; of these the source of French Prunes is var. *Juliana* D. C., that of German Prunes var. *Œconomica* Bork; but other varieties are also dried, and it is to be doubted whether the source of any particular sample can be always determined. Plums have been cultivated for more than twenty centuries. Prunes need no description, they are kept in large quantities by the grocers, in every quality, from the poorest, in bulk—small, excessively shrivelled, hard, and nearly tasteless—to the best, imported in glass jars or fancy boxes.

They contain *sugars* and *fruit acids* (malic, etc.), "*pectic* and *albuminoid substances*," etc., and are chiefly consumed as dessert, or in sweet sauces, puddings, or pies. In large quantities they are a slightly laxative food; they

can scarcely be called medicine, and would be dropped from the officinal list, only that they are employed in the Confection of Senna (*Confectio Sennæ*, U. S. Ph.), of which they compose seven per cent. The syrup of "stewed prunes," made thick and sweet, is an excellent laxative for infants; they take it readily, and it produces very little unpleasant disturbance. Dose, a teaspoonful.

Allied Plants.—See Almonds.

Allied Drugs.—Figs, Raisins, Tamarinds, Cassia Fistula, etc.

W. P. Bolles.

PRURIGO. Syn.: Prurigo (Hebra); Juchblattern, Ger. Before Hebra described a distinct disease under the name of prurigo, the term included a number of affections which were dissimilar in various respects. Almost anything which had *itching* as one of the symptoms was liable to be put down as a form of prurigo. Pruritus was prurigo, and prurigo was pruritus—a confusion of terms which still to a large extent exists among the older general practitioners. They should not be confounded, for the dermatologist recognizes prurigo as a disease *sui generis*, while pruritus is only a symptom.

Prurigo is a rare disease in North America. The reports of the American Dermatological Association for the last three years give 19 out of a total of 38,320 cases of skin diseases reported by the different members. Foreign dermatologists are incorrect in suggesting that the disease is overlooked in this country. The fact is, it hardly exists here; and if cases are seen, they are most often in those who have come into the country from abroad, bringing it along with them.

As described by Hebra, the disease is divided into prurigo simplex seu vulgaris and prurigo agria seu ferox, according to its severity and duration. It always begins in early life, and is generally foreshadowed by the appearance, upon the extremities of an infant, of constantly recurring urticarial wheals. After the second year of life an eruption of small papules, the size of a mustard- or hemp-seed, makes its appearance, and we then have true prurigo.

Primarily, the papules are more perceptible to the touch than to the sight. The hand when run over the skin feels the minute nodules before the eye can detect them, projecting above the level of the surrounding epidermis. As time goes on, this roughness of the skin to the touch is even more pronounced, so that the hand feels as if it were being rubbed upon coarse sand-paper.

After the papules appear, itching commences, and the child is seen to scratch. A drop of clear-colored serum forms a vesicle at the top of the papule, the epidermis becomes thin, is then scatched off, and the serum escapes, while further scratching may rupture the capillaries already dilated, forming a crust of blood and serum. After years of recurring eruption and scratching, the skin becomes thickened, hardened, brittle, parchment-like, and pigmented. The patients are unable to resist the impulse, and spend the greater part of their lives in scratching. Even in sleep there is no cessation. Unconsciously, all night long they are at work, so that the regular grating sound, coming from the beds of long-suffering prurigo patients at night, is one of the most weird and unpleasant noises imaginable. It is as regular as their breathing.

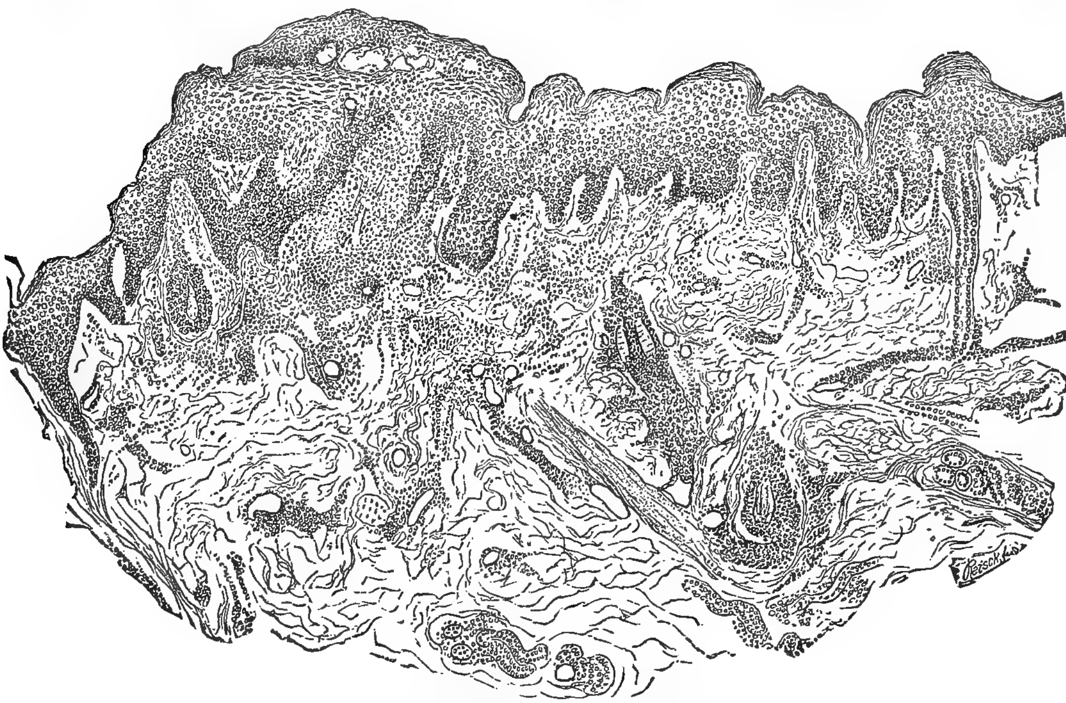

Fig. 3128.—Prurigo Papule.

The disease most generally begins upon the extremities, where it is also most intense. The papules appear first in this situation, and then, in order, upon both sides of the thorax, the abdomen, the back, and the buttocks. They do not appear on the scalp, and seldom in the axilla, the palms, the flexor surface of the knee-joint, or on the genitals. In cases of long standing the lymphatic glands are enlarged.

Histological investigation of the papule, made by the present writer,[1] shows that it is formed by an infiltration beginning around the upper layer of vessels of the corium; this infiltration, extending upward, surrounds the papillary vessels and enlarges the papillæ, thus pushing up the epidermis, which becomes thickened at an early stage above them (see Fig. 3128). Finally, this infiltration, penetrating the epidermis, forms with its layers a small vesicle containing serum, blood, and lymph-cells. The signs of infiltration surrounding the hair-sheaths and sweat-ducts are secondary, and they play no especial part in the process. Their presence in the papule is ac-

cidental, and it is certain that the primary changes in the skin are not in connection with them.

The color of the papule at first does not differ from that of the surrounding skin, on account of the depth of the slight infiltration with which it begins. At this stage there is no itching, but later on, when the infiltration has become greater this symptom begins.

Hebra says prurigo is incurable; the symptoms may be alleviated by proper remedies, but there is no permanent cure. The therapeutical indications are to remove the dry, brittle epidermis, to soften the skin, and to allay the itching. Warm baths, continued for hours at a time; stimulating soaps, such as spiritus saponis alkalinus; ointments of vaseline, lanolin, or simple cerate, containing zinc, salicylic acid, or sulphur; medicated gelatines, and attention to the general health, are some of the means employed to relieve the sufferer. It is a disease of the poorest, most ill-fed classes—such classes as know no hygienic laws, and have for successive generations been in the same unhealthy condition. Fortunately, we have as yet no such classes in this country; hence the rarity of the disease with us.

Robert B. Morison.

¹ A Contribution to the General Knowledge Concerning the Prurigo-Papule, American Journal of Medical Sciences, October, 1883.

PRURITUS. A neurosis of the skin, characterized by local or general itching, without any perceptible primary lesion.

PRURITUS UNIVERSALIS usually affects larger portions of, or even the entire surface, and may occur at any age or in either sex. It is not infrequently accompanied by some disturbance of the abdominal organs, as granular liver, hepatitis, Bright's disease, etc. In young women, disturbance of the menstrual functions and, in older women, pregnancy sometimes occupy a causal relation to general pruritus. In still older persons, and especially in the aged, general pruritus not infrequently occurs in its severest and most stubborn form, probably in connection with the senile changes in the skin, forming a most distressing malady.

PRURITUS LOCALIS occurs commonly in certain regions by preference. Thus we have *pruritus ani,* which usually occurs in connection with hæmorrhoids or, in children, with seat-worms. The affection usually first shows itself at the muco-cutaneous junction, and spreads forward toward the perineum and backward toward the coccyx. Pruritus ani is usually worse in the evening on undressing, and when the patient becomes warm in bed. In the semi-unconsciousness of sleep the parts are rubbed and scraped until an artificial eczema results, and, in fact, more or less eczema is present in most severe cases of pruritus ani.

Pruritus genitalium takes on a somewhat variable aspect, according to the sex. In men the scrotum is the usual seat of the disease. Pruritus scroti is a not infrequent accompaniment of pruritus ani. In the earlier stages of the disease no lesions are perceptible, but after the affection has lasted for some time excoriations and blood-crusts appear as secondary lesions, the result of scratching. Here, too, artificial eczema sooner or later results, although the writer has observed numerous cases where, even after prolonged and severe pruritus, no perceptible lesions could be observed upon the scrotum. Pruritus scroti is always a stubborn affection, and sometimes becomes chronic, resisting every attempt at relief, and at times driving the patient nearly frantic.

Pruritus pudendi muliebris commonly occurs in the mucous membrane about the labia minora and majora, and in the neighboring muco-cutaneous surface. Occasionally it seems to be confined to the clitoris and its immediate surroundings. In children, ascarides are often the cause of the itching; in adult females, uterine disease, leucorrhœa, vaginismus, etc., give rise to the trouble. Not infrequently, however, no known cause can be ascertained, and the affection appears to be purely idiopathic. European writers often allude to this affection as the cause of onanism and nymphomania. The writer has never observed this result excepting among the insane, and is not disposed to regard pruritus pudendi as a frequent cause of these neurotic manifestations in persons enjoying the full use of their mental faculties. This form of pruritus is connected at times with diabetes mellitus.

Pruritus palmaris and plantaris are forms of local pruritus which may be mentioned. They are rarely severe or long continued, and are usually more amenable to treatment than the other forms.

A form of local pruritus due apparently to changes of temperature is that first described by Duhring as *pruritus hiemalis,* or winter pruritus. This form is commonly observed upon the lower extremities, particularly the insides of the thighs and the calves, although sometimes it may occur upon the upper extremities, and may assume an almost universal form. The peculiarity of pruritus hiemalis is that it leaves its victim free during the summer months, only to return promptly with the frosts of autumn, year after year. During the winter months a spell of clear, bright, frosty weather will bring on a tormenting attack, which will pass away when the weather becomes warm and moist. The itching comes on when the patient takes off his clothing at night, and seems to be excited by the impact of cold air. In the majority of cases it passes off as the patient grows warm in bed. Severe cases may, however, continue through the entire day, and even torment the patient at night.

The *diagnosis* of pruritus should give rise to no difficulty, because, although there are other diseases in which itching is a prominent symptom, these are always characterized by primary lesions of some sort. The history of itching as the first symptom, with visible lesions occurring only secondarily, if at all, is conclusive.

Old cases of pruritus are almost always accompanied by a certain amount of eczema, with scratch-marks, papules, fissures, crusts, pigment-deposit, etc., and it may at times require careful investigation to ascertain the character of the original disease. Of course, the possible presence of parasites must always be considered and excluded (see Pediculosis).

The *treatment* of pruritus is always difficult, and will at times require every therapeutic recourse and the most careful examination and study of the patient's whole economy.

There are few skin diseases in which it is more necessary to examine every possible weak point, and yet cases not infrequently occur in which the practitioner must proceed on a basis of pure empiricism, and simply employ one remedy after another until something or some combination is secured which will attain the desired end.

As regards drugs, the usual tonic and alterative medicines are to be employed. Irregular menstruation must be treated by the judicious use of iron or other remedies, cod-liver oil, etc. Quinine and strychnine are sometimes of use. Recourse may be had to bromide of potassium and chloral, alone or together, in order to subdue general nervous symptoms. Morphia should in no case be used, as it tends to aggravate the itching.

External treatment affords great relief, and is to be used in all cases. Hot and cold douches, used alternately, or hot water applied as hot as it can be borne, or plain vapor-baths, are often useful. Medicated baths, containing from three to six ounces of bicarbonate of sodium, or from two to four ounces of carbonate of potassium or borax, to thirty gallons of water, will at times afford relief. Sulphuret of potassium and sulphur vapor-baths are sometimes used with success. Inunctions with a bland oil, as almond-oil, may be practised after these baths.

Lotions of various kinds are the most generally useful applications in pruritus, and those containing carbolic acid are by far the most generally efficient. Chloroform; chloroform and alcohol, a drachm to the pint; lead-water; dilute water of ammonia; dilute nitric acid, ten minims to the ounce of water; vinegar—are all serviceable remedies which may be tried singly or in succession

in troublesome cases. The following tar-preparation, known as liquor picis alkalinus, and introduced by Bulkley, is generally useful: ℞. Picis liquidæ, 64 Gm. (℥ ij.); potassæ causticæ, 32 Gm. (℥ j.); aquæ, 160 Gm. (℥ v.). M. This is very strong and must be diluted with from three to ten parts of water. In some localized forms of the disease, ointments are to be used in preference to lotions. One of carbolic acid, ten to fifteen grains to the ounce of oxide of zinc, is often useful.

In pruritus of the female genital organs, water as hot as can be borne, sponged upon the parts, forms an admirable anæsthetic and should be used in all cases, whatever other treatment may be added. Following this, carbolic lotions, sulphurous acid—sulphite of sodium, in solution of a drachm to the ounce of water—and lotions containing hydrocyanic acid may be employed. Sometimes an emollient poultice of freshly made almond-meal, which evolves a small quantity of hydrocyanic acid, will be found very soothing. Where the itching is localized, particularly about the clitoris, a ten-per-cent. solution of hydrochlorate of cocaine, painted on, will give an exquisite sense of relief for a time, and may even prove curative.

Pruritus of the anus is best treated by oils or ointments. Carbolized oil, in the strength of twenty per cent., and ointments of belladonna or tar are usually beneficial. Applications of hot water should precede the use of the medicinal agents. Sometimes a pledget of lint wet with a five-per-cent. solution of hydrochlorate of cocaine will relieve the pruritus like magic.

Pruritus of the scrotum is often very intractable, the more so because the skin is thin and not infiltrated and its surface is intact. It is difficult to get any local remedies in direct contact with the diseased parts. The following formula is much used: ℞. Bismuthi subnitrat., 8 Gm. (ʒ ij.); acid. hydrocyanic. dil., 8 Gm. (f ʒ ij.); mist. amygdalæ, 32 Gm. (f ℥ iv.).

In the pruritus of jaundices, mercurial ointment is said to be of value; also, lotions and baths of vinegar, in the proportion of two quarts to an ordinary thirty-gallon bath, or of nitric acid, in the proportion of two to three ounces to the bath.

The *prognosis* of pruritus should be guarded. The disease, as a rule, is obstinate; often extremely so. The prognosis often depends largely upon the cause and our ability to remove it. In grave cases melancholic symptoms may be present. Occurring in the aged, the prospect of ultimate cure is poor.

Pruritus hiemalis, though usually less severe, is perhaps even more intractable than the other forms of the disease. *Arthur Van Harlingen.*

PSORIASIS. A chronic affection of the skin, characterized by the appearance of reddish, slightly elevated, dry, inflammatory patches, variable as to shape, size, and number, covered with abundant, whitish or grayish mother-of-pearl-colored, imbricated scales. The disease varies greatly in its extent and intensity in different cases, sometimes showing a typical development, in other cases represented by one or two obscure lesions. It possesses, almost invariably, however, certain characters which serve to identify it. The lesions begin as small, reddish spots, scarcely raised above the level of the skin, which almost immediately become covered with whitish scales. They often develop rapidly, reaching the size of coins in a few weeks. At other times the course of the disease is more sluggish. The extent of the eruption varies greatly. A few patches may be all that are present, or the entire surface from head to foot may be involved, with scarcely a clear spot to be found. Commonly the disease shows itself in the form of scaly patches, of varying size, scattered over different parts of the body. The patches are characteristic. They are usually rounded, sharply defined from the surrounding skin, and consist of a mass of imbricated, yellowish-white scales on a red base. When the scales are picked off, a smooth, shiny, reddish surface is shown underneath, on which can be perceived a few drops of blood the size of pin-points. The abundance of the scales is a marked feature in some cases. Where they are formed rapidly—that is, in well-developed cases—the patient's bed may be filled in the morning with a handful of scales which have accumulated during the night. When the disease exists about the joints, fissures may show themselves, so deep at times as to make movements of the affected limb painful. There is no watery discharge at any period of the disease. Sometimes the eruption takes on a highly inflammatory character, with redness, swelling, and severe burning and itching, while at other times all these symptoms are much less marked, and, in fact, the patient would hardly be aware of the existence of the disease, did he not see the eruption. Though the individual patches of psoriasis may be, and generally are, small, yet they sometimes coalesce into patches the size of the hand or larger, or may even cover the greater part of a limb.

Psoriasis may occur on any part of the body, but is most apt to be seen on the extensor surfaces of the limbs. It is sometimes found on the elbows and knees when it shows itself nowhere else. On the other hand, it may be absent from these localities, although present at many other points. The back is more commonly attacked than the chest, and in women a favorite seat of the eruption is around the waist where the skirts are tied. The scalp is a frequent seat of the disease. In this locality it sometimes occurs in patches, but more frequently as a diffuse and abundant scaliness. It is apt to extend a little beyond the border of the scalp, especially behind the ears and on the forehead, and this is quite characteristic. Psoriasis does not occur upon the mucous membranes. The so-called "psoriasis" of the tongue is probably only a precursory hardening leading to epithelioma. Psoriasis is not contagious.

The cause of psoriasis is not known. It is apt to occur in well-nourished, rosy-complexioned, light-haired people, the "picture of health" excepting that they are apt to be a little rheumatic. Now and then, however, it is met with in thin, worn persons who are in poor health. Greenough's statistical inquiry into this point confirms the writer's view. Psoriasis is not often encountered in children, though Stelwagon has reported a case where it occurred in a child between three and four years of age, and Greenough's statistics show of 150 cases 20 which were known to have first occurred under the age of ten. On the other hand, 6 cases out of those observed by Greenough first showed signs of the disease after passing the fiftieth year. It is the opinion of the writer that psoriasis occurs much more generally than is supposed at an early age, but the disease is not apt to be noticed until it grows with the growth of the individual and becomes more pronounced. Greenough succeeded in obtaining a history of hereditary or family tendency in 31 cases out of 97, but the tendency to hereditary transmission has not been observed by most writers or has been considered rather exceptional. Some cases of psoriasis are worse in winter and disappear almost or entirely in summer; others are worse in summer. Diet, I believe, has little influence in causing the disease, though in some cases it may influence its course quite markedly. Psoriasis and syphilis are not connected in any way. There is a syphilitic eruption sometimes called "syphilitic psoriasis," because the lesions resemble those of psoriasis. This most unhappy term has caused much confusion of mind, but it must be remembered that the cause, course, and treatment of syphilis differ *in toto* from those of psoriasis (see under Syphiloderma).

The diagnosis of psoriasis is easy when the affection is well developed and presents its typical appearance. The form and aspect of the lesions, and the history of the case, will usually serve to determine its nature. Scanty and ill-developed eruptions of psoriasis are, however, at times distinguished only with difficulty. Nevertheless, it is an important matter to accurately determine the nature of the disease, for its treatment is widely different from that of the affections with which it is liable to be confounded; its prognosis is also different, and, in addition, two of the other affections are contagious.

Two or three small patches of psoriasis occurring alone

upon the arms or legs may be mistaken for *eczema*. Itching, however, is almost invariably present in eczema, and therefore itching is one sign that an eruption in question is not of this nature, though not a sure sign, since psoriasis also sometimes itches.

In the majority of cases of eczema there will be a history of moisture at some time. Psoriasis is always dry and scaly, never moist. The scales of psoriasis are more abundant, larger, and whiter than those of eczema. The patches of psoriasis are usually bold and well defined in outline, while those of eczema fade into the surrounding skin.

Syphilis in the form of the papulo-squamous syphiloderm is very apt to be mistaken for psoriasis, and *vice versâ*. Psoriasis, however, is more apt to be symmetrical in its distribution. It often involves a large portion of the surface at once, or is found in regions remotely separated, which is rarely the case with the papulo-squamous syphilitic eruption. In psoriasis the lesions seem to be on the surface, so to speak. They are very scaly, but without much infiltration. The syphiloderm, on the other hand, is deeply indurated, and is only scantily covered with scales. In psoriasis the knees and elbows are apt to be involved. In syphilis these are not often attacked. Occurring on the palms and soles the disease is almost certain not to be psoriasis, which is very rare in this locality. The color, though often deceptive, sometimes aids in diagnosis. It is usually much lighter in psoriasis, while in syphilis it is apt to be a dusky ham-color. The age of the patient and the duration of the disease may give a clew to the diagnosis. Psoriasis generally first shows itself before the age of twenty; this form of syphilis, later. The history of psoriasis is that of a chronic disease lasting for years, continuously or in an intermittent manner. Syphilis rarely retains one form for any length of time. Other points in the history—infection, the occurrence of other lesions, etc.—may come into use. Itching is rare in syphilis, common in psoriasis, but too much reliance must not be placed on this symptom. It has been the writer's misfortune to see several lamentable mistakes made by the exclusion of syphilis based on the presence of itching. Finally, the touchstone of treatment may be resorted to in very obscure cases.

Tinea circinata and psoriasis are sometimes mistaken for one another, but the patches of tinea are less inflammatory, red, and infiltrated, and are much more superficial. The scales in tinea are larger and lighter, and the patches show no attempt at symmetry. The microscope shows the existence of a fungus in the scales of tinea circinata, which is absent in psoriasis, and a history of contagion may often be obtained in the former disease, which is absent in the latter.

Psoriasis may occasionally be mistaken for seborrhœa, as this disease occurs on the chest and back. A comparison of the description just given of psoriasis with that of the former disease will show in what points the difference lies, while it may also be kept in mind that seborrhœa affects a small patch, the size of the hand, over the sternum in front and the region of the scapulæ, with the parts between them, behind. From seborrhœa capitis and from pityriasis capitis, psoriasis of the scalp is distinguished by the yellow, friable character of its scales and their abundance, the scales of seborrhœa being markedly oily and adherent, while those of pityriasis are gray, thin, and powdery.

Psoriasis may occasionally be mistaken for lupus, especially lupus erythematosus; but in addition to the fact that lupus erythematosus is most likely to be encountered on the face alone, whereas psoriasis is almost always found coincidently in other localities, the more scanty scaliness of lupus and the greater amount of infiltration also serve to distinguish between the two affections. The description of both forms of lupus may be referred to in this connection.

It is said that psoriasis may be confounded with lichen ruber. This certainly cannot occur very frequently in this country, the forms of lichen ruber commonly encountered here being easily distinguishable. Lichen ruber usually occurs upon the extensor surface of the forearms, at least in the milder cases; the lesions are uniformly of small size, not much larger than a pin-head or small split-pea, while the lesions of psoriasis vary from the size of a pin-head to that of a coin, with occasional larger patches. The lesions of lichen ruber have few scales, while the lesions of psoriasis are very scaly.

The anatomy of psoriasis has been made the subject of careful study by Robinson, whose description shows the affection to consist in a hyperplasia of the rete and corresponding structure of the hair-follicles. In a section of a lesion of a few days' duration the corneous layer is found to be but slightly changed. Prolongations downward of the interpapillary portion of the Malpighian layer, which are more extensive in the central, *i.e.*, older portions of the lesion, are seen in microscopic sections of older lesions. In the papillæ and superficial part of the corium within the psoriasis regions there are seen enlarged blood-vessels and round bodies in varying numbers in the surrounding tissues, while in the non-papular region no enlargement of blood-vessels is as a rule observed, and also no white blood-corpuscles. The deeper parts of the cutis appear normal, as well as the sebaceous and sweat-glands.

The increase in the thickness of the Malpighian layer arises from an increase in the number of rete-cells. This increase is sometimes very great. The blood-vessels, also, in the papillæ are more or less dilated, this dilatation, together with the emigration of white blood-corpuscles, increasing with the duration of the eruption. All the inflammatory changes, however, in the cutis are secondary to the hyperplasia of the rete.

The hair in psoriasis becomes changed at the commencement. The external root-sheath, the structure cor responding to the rete, becomes increased in size in the same manner as the latter structure. There is a real hyperplasia, with an extension of the hyperplastic structure into the surrounding cutis. This growth occurs principally at the root of the hair, though it is met with also along the rest of the follicle.

During the period of disappearance of the disease there is a gradual return to the normal condition, until the hyperplasia, dilatation of the blood-vessels, and cell-infiltration have completely disappeared. The Malpighian prolongations become smaller and smaller until the layer attains its normal size; the blood-vessels gradually return to their normal diameter, and the round cells and serous exudation to their normal channels. Of these pathological processes, the cell-infiltration and œdema generally disappear first, and the hyperplasia last. Psoriasis may sometimes undergo degenerative changes and become changed into epithelioma, as has been shown by White.

The *treatment* of psoriasis must be in most cases both internal and external. The constitutional treatment of the affection should be based on a careful study of the history and habits of the patient. Attention should be given to the patient's general health and his condition, whether stout and well nourished or thin and delicate. Regard must be had also to any functional derangement. The history of the eruption itself must be inquired into, as to its acuteness or chronicity, as to local and constitutional treatment which may have been previously employed, together with the effects of the same. In addition, inquiry should be made regarding the influence of the seasons, and whether the eruption is apt to disappear for a time and then to break out again.

Fortified with this knowledge, the medical treatment can be entered into intelligently. In the large majority of cases, arsenic is pre-eminently the remedy. But while arsenic is as near a specific as, in the nature of things, it is possible for any medicine to be, yet it must be employed judiciously if its good effects are to be obtained, or even if we do not wish to do harm. Arsenic should not, as a rule, be administered where there is much gastric irritation, and it is hardly necessary to say that it should not be continued, should it disagree even slightly. The patient should be warned of its possible effects, and should be under the constant watch of the physician; on the first symptom of indigestion, pain in the stomach or

bowels, or diarrhœa, the dose should be lessened or the use of the medicine suspended. Large or almost toxic doses do not hasten the cure of psoriasis; they sometimes even retard it by upsetting the stomach. Sometimes only a minute dose, as half a minim of Fowler's solution, is borne at first, when, later, tolerance is gained and a full dose may be given. Some persons need and will bear large doses of arsenic, but this idiosyncrasy must be learned by careful tentative increase of the dose, beginning always with a moderate one. Arsenic should not usually be given in acute and inflammatory forms of psoriasis. Arsenic acts slowly. Where in a case of psoriasis it is going to do good, improvement generally begins to be shown after two or three weeks; but to get the full benefit of the drug it must be given for several months, and its administration should be continued for several months after the eruption has disappeared.

The best form in which to administer arsenic is, in the great majority of cases, unquestionably that of "Fowler's solution"—Liquor Potassii Arsenitis—of which five drops contain about one-twentieth of a grain of arsenious acid, the average dose. The medicine should never be given in drops, as mistakes are likely to occur. A very good formula, and the one almost always employed by the writer, is the following: ℞. Liq. potas. arsenit., Gm. 8 (ʒ ij.); vini ferri, ad Gm. 128 (f ℥ iv.). M. Sig.—Teaspoonful three times a day, after meals. The dose here is four minims. The amount may be gradually increased, say, every three days, until an effect upon the eruption becomes perceptible, or until the limit of tolerance is reached.

Sometimes it is desirable to give the arsenic in pill-form: ℞. Pulv. acidi arseniosi, Gm. .14 (gr. ij.); pulv. piperis nigræ, pulv. glycyrrhizæ rad., āā Gm. 3 (℈ij.). M. et div. in pil. No. xl. Sig.—One, after meals. Or, occasionally, powders may be preferred: ℞. Pulv. acidi arseniosi, Gm. .14 (gr. ij.); pulv. sacch. lactis, Gm. 10 (gr. cl.). M. in chart No. xl. div.

But neither pills nor powders are as effective as Fowler's solution, and the writer rarely prescribes them unless forced to do so by circumstances.

Various other specifics have been recommended for psoriasis at different times; tar, carbolic acid, turpentine, phosphorus, and iodide of potassium may be mentioned. None of these, however, has stood the test of time.

Some cases of psoriasis require, instead of the specific treatment, one directed against the patient's general condition. In debilitated cases, cod-liver oil, iron, the hypophosphites, etc., are useful. In thin, worn-out women, as nursing mothers, where the attack has come on during lactation, iron is imperatively called for. Next to iron is cod-liver oil, and these remedies occasionally succeed where arsenic fails. In acute inflammatory cases, diuretics are occasionally of service. Acetate of potassium, in half-drachm doses, may be given three or four times a day, in a wineglass of water. The alkaline mineral waters are also of service.

The local treatment of psoriasis is of more or less importance, according to the nature of the case. Where the lesions are few, small, and widely disseminated, and there are no disagreeable subjective symptoms, local treatment is inconvenient, and need not be employed. Where, however, there are a few large patches, or where the eruption is situated on some conspicuous part of the person, or gives rise to annoying burning or itching, local treatment is required, and will be found advantageous. If there are scales, these should first be removed by rubbing with sapo viridis and hot water, or by the use of a hot-water bath. If the patches are few in number, large, and very scaly, the following solution, well rubbed in, will remove the scales readily, and give an opportunity for making healing applications: ℞. Acid. salicylici, 4 Gm. (ʒ j.); alcoholis, 64 Gm. (f ℥ ij.). This is especially useful upon the scalp. After the scales have been cleaned off by this means, or by means of spiritus saponis alkalinus (two parts of sapo viridis dissolved in one part of hot alcohol, and filtered) used as a shampoo, an oil composed of one drachm of oil of cade to the ounce of oil of almonds or alcohol may be well rubbed in with the aid of a brush. On the edge of the scalp and about the face the best ointment is that of ammoniated mercury, twenty to forty grains to the ounce.

Where it is desirable to get rid of the scales and patches in the most rapid manner possible, chrysarobin is the best application. An ointment of half a drachm to a drachm to the ounce is very efficient, and will remove a patch in a few days, leaving a white spot of skin surrounded by a purplish areola in its place.

There are strong objections to the use of chrysarobin, however. It discolors everything with which it comes in contact, dyes the hair orange-yellow, and spoils the clothes. It cannot be used on the scalp or about the eyes and cheeks, because it induces inflammation there, and it cannot be trusted in the hands of most patients, because, unless used cautiously, it may inflame the skin wherever used. G. H. Fox has suggested the following solution, which is effectual, though decidedly less so than the ointment, and which saves the smearing which renders the chrysarobin ointments so annoying and disagreeable: ℞. Chrysarobin, 4 Gm. (ʒ j.); ætheris et alcoholis, āā q. s.; collodii, 32 Gm. (℥ j.). M. Rub up the chrysarobin with a little alcohol and ether and add to the collodion. It forms a sort of emulsion, which should be shaken before using. By the aid of a camel's-hair pencil in the cork this may be painted over the affected patches after removal of the scales. When it dries it will not come off on the clothes, which is a great advantage.

Next to chrysarobin in activity comes pyrogallic acid. This may be used in ointment, a drachm to the ounce. It is not so effectual, but is much more cleanly, although it leaves a blackish stain. It should not be employed over a very large area at once, for fear of absorption.

Preparations of tar have been used from time immemorial in the treatment of psoriasis. They are particularly useful when there is a good deal of itching. Pix liquida and oleum cadinum are the forms most commonly employed, either in ointment or dissolved in alcohol in the proportion of one or two drachms or more to the ounce. The solution known as "Tinctura Saponis cum Pice" is a useful application; it is composed of equal parts of sapo viridis, pix liquida, and alcohol. Wilkinson's ointment is also useful, owing its virtues partly to the sulphur which it contains. The formula for it is as follows: ℞. Olei cadini, flor. sulphuris, āā 12 Gm. (ʒ iij.); saponis viridis, adipis, āā 24 Gm. (ʒ vj.); cretæ, 1.7 Gm. (gr. xxvj.). These preparations should be rubbed firmly into the diseased patches, once or twice daily.

In very severe or extensive psoriasis, baths, with the inunction of bland oils and fats, are better than any of the applications mentioned. Tar may be used at times, but with caution.

The *prognosis* of psoriasis, so far as the individual attack is concerned, is in medium and mild cases usually favorable. But the disease is prone to relapse, and the patient should be warned that while the attack can be cured, the affection is liable to return, and that no treatment, however well directed, will surely prevent the disease from coming back. Severe cases especially, when almost the entire surface is covered with the disease, are often rebellious to all treatment.

Arthur Van Harlingen.

PTERYGIUM (πτερυξ, a wing). A circumscribed hypertrophy of the conjunctiva and subconjunctival tissue, triangular in shape, more or less vascular, and exhibiting a tendency to encroach upon the cornea. The apex of the growth is always turned toward the centre of the cornea, the base toward the equator of the eye. Its usual location is to the nasal side of the cornea, over the region of attachment of the tendon of the rectus internus to the sclerotic; exceptionally it occurs to the outer side of the cornea, and still more rarely above or below it. It usually develops very slowly, and many months, or even years, may elapse without its extending far enough toward the centre of the cornea to impair

vision. It is rarely met with in children, and is more prevalent in tropical than in temperate countries. The apex of a pterygium not infrequently reaches, but rarely passes beyond, the centre of the cornea. The writer has met with one case, however, in which a pterygium of unusually large size, starting from the nasal side of the eye, grew entirely across the cornea to its external margin. The other eye of the same individual (a woman, advanced in years) also exhibited a large pterygium, which had already passed beyond the centre of the cornea. So long as the growth is confined to the conjunctiva and the periphery of the cornea it usually causes little or no inconvenience, but as soon as it encroaches upon the area of the pupil it greatly impairs vision, not only because, being opaque, it obstructs the passage of light into the eye, but because the curvature of the corneal surface about its apex is so altered as to produce a high grade of irregular astigmatism.

In the text-books of forty or fifty years since, four or five varieties of pterygium are described. There seems to be little reason, however, for making even the two varieties which more recent authors mention; although, as some pterygia are thin and scantily supplied with blood-vessels while others are thick and vascular, there is some warrant, perhaps, for calling the former variety *pterygium tenue*, and the latter *pterygium crassum*. The *pterygium pingue* of the older authors is the pinguecula of the present day, which is no longer regarded as a variety of pterygium; while their *pterygium malignum* was, as its name implies, simply a malignant growth involving the cornea, which at the present day we would, of course, not think

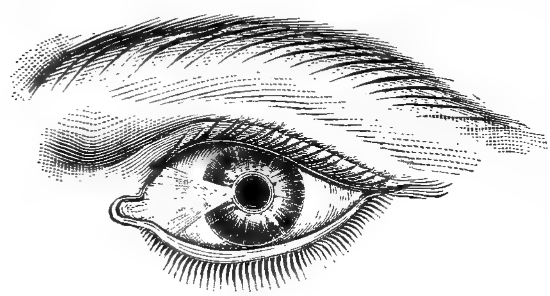

FIG. 3129.—Pterygium.

of confounding with true pterygium. It is possible for several pterygia to develop upon the same eye, advancing upon the cornea from different directions, and cases of this character have been reported, but they are of extreme rarity.

The question of the *pathogenesis* of pterygium has, from time to time, been discussed, and various theories have been suggested to account for its development and growth. None of those so far advanced seems, however, to be satisfactory. Arlt, some years ago, suggested that the starting-point of pterygium is the existence of a superficial ulcer or abrasion at the margin of the cornea, to which the neighboring swollen conjunctiva becomes adherent, and that the dragging and irritation which results from this is the cause of its subsequent growth; and this theory has met with very general acceptance. It takes no account of the fact, however, that ulcers and abrasions of the cornea are not especially frequent upon its nasal margin, while pterygium, as we have seen, occurs only very rarely elsewhere; nor of the further fact that many cases of pterygium can be recognized as such before the apex of the growth has even reached the corneal limbus, and, therefore, before the process which is assumed to be the first step in its development has taken place. That pterygium is produced in this manner, in exceptional cases, there is no doubt; but this fact was recognized before Arlt's day—notably by W. Lawrence,[1] who refers to cases of pterygium following purulent ophthalmia, in which the conjunctiva from the upper part of the globe had become adherent to an ulcer upon the lower part of the cornea.* He distinguishes, however, between these cases and true pterygium, and mentions his suspicion that the pterygia said to have been seen on the upper part of the globe were cases of this character, as he had never seen true pterygium in this situation.

It is manifest that any theory which would satisfactorily account for the development of pterygium must also account for the fact that it occurs in so large a proportion of cases to the nasal side of the cornea. This Arlt's theory fails to do; for it is beyond question that if pterygium were, as a rule, produced in the way he describes, we should find it encroaching upon the cornea from every possible direction, and not much more frequently from one direction than from another. The theory more recently proposed by Poncet, that pterygium is a parasitic disease, and that its advance over the cornea is due to the presence of microbia—parasitic "vibriones," which he finds beneath the head of the pterygium, and which are supposed to tunnel their way under the corneal epithelium—fails equally in this respect; and, besides, the precedent ulcer which he regards as the starting-point of the process, and as essential to it, has not been clinically demonstrated, but, rather, assumed to have been present.

In endeavoring to reach a satisfactory explanation of the origin of pterygium, it is important that we should bear in mind the fact (which seems usually to have been lost sight of) that in its incipient stage the growth does not, as a rule, involve the cornea at all, but is confined to the sclerotic conjunctiva. As Lawrence very aptly puts it: "It begins with the appearance, in the conjunctiva scleroticæ, of a few vessels rather larger than natural, and running from behind forward nearly parallel to each other. After some time the membrane is found, on accurate inspection, to be a little raised, but the surface is smooth and entire. It gradually assumes the triangular shape, the basis extending toward the circumference of the eye, while the apex passes over the junction of the sclerotica and cornea and advances on the latter."[2] This description of the development of pterygium entirely agrees with the writer's own observations, and it suggests at once that the primary cause of pterygium is to be sought for elsewhere than in diseased conditions of the cornea.

It has long been taught that the development of pterygium is favored by conditions which bring about persistent hyperæmia of the conjunctiva, as, for example, when the eyes are exposed to the heat of a tropical sun, as in long sea-voyages, or to the heat from furnaces, as is the case with stokers and founders, or to the irritant action of dust and vapors, as in mills and other manufacturing establishments; and the evidence in favor of this view is much too strong to be put aside. Assuming, then, that hyperæmia of the conjunctiva is an important factor in the production of pterygium, are there reasons why this condition should occur especially where pterygium usually makes its appearance—to the nasal side of the cornea? The writer does not hesitate to answer this question affirmatively. He is not aware that it has been suggested, heretofore, that the recti muscles of the globe have anything to do with the production of pterygium; but it seems to him highly probable that such is the case. In the first place, it is well known that it is an extremely rare occurrence to meet with a pterygium which does not lie directly over the insertion of one of these muscles—they scarcely ever approach the cornea except in an exactly horizontal or vertical direction. Again, the vascular system of the conjunctiva in the neighborhood of the corneal border (anterior conjunctival vessels of Van Woerden) is so intimately connected with that of the recti muscles, through branches derived from the anterior ciliary arteries, that the possibility of the blood-supply of the former being influenced by that of the latter can scarcely be doubted. There is nothing improbable, therefore, in the assumption that the determination of blood to the recti muscles may bring

* The writer has also met with a case of this character as a result of gonorrhœal conjunctivitis. Only the apex of the pterygium, however, was adherent to the cornea, and a probe could be passed between the corneal surface and the body of the pterygium.

about a hyperæmic condition of the overlying conjunctiva, and that this condition, as we have seen, may in time lead to the development of pterygium. Moreover, it is manifest that the recti interni muscles would be likely to exert a much more decided influence in this respect than any of the others; for they are not only the largest of the straight muscles, and the ones which perform by far the greatest amount of work, but their attachment to the sclerotic is considerably nearer the corneal border, and they are, therefore, more intimately connected with the conjunctiva. Thus the location of pterygium to the nasal side of the cornea is at once explained.

In support of this view as to the origin of pterygium, which, to the writer, seems at least to be more satisfactory than those which have as yet been offered, it may be mentioned, as a matter of observation, that persons who have pterygium not infrequently complain that the pterygium itself, and the conjunctiva in its neighborhood, become bloodshot when the eyes are much used in near work. How far insufficiency of the internal recti muscles may influence the development of pterygium is a question which at once suggests itself, and which calls for investigation. Although the writer has, as yet, but little evidence to offer bearing upon this point, he is disposed to think that this and other disturbances in the muscular balance of the eye play an important rôle in the pathological process under consideration. It remains to be added that pterygium sometimes has its origin in traumatic lesions of the conjunctiva, as, for example, to cite from the writer's experience, a burn from a scale of hot iron or from partially slaked lime splashing into the eye.

In regard to the *treatment* of pterygium, little is to be expected except from operative interference. In its incipient stage, however, its growth may possibly be arrested by correcting, by means of glasses, any error of refraction or any muscular defect which may exist; and, even when it has reached a more advanced stage, its development may, perhaps, be favorably influenced in this way. So, too, after any operation which may be resorted to for its cure, the good which glasses may do by lessening the tendency to a recurrence should not be lost sight of. It should be borne in mind that the asthenopic symptoms, of which persons suffering with pterygium often complain, are much more likely to be due to some error of refraction or muscular defect than to the mere presence of the growth. The propriety of resorting to operative treatment will be determined by several considerations: If the pterygium be confined to the conjunctiva, it may be advisable to operate upon it, provided it be narrow and well defined. If, on the contrary, it be broad and ill defined, it will be wiser not to interfere with it, as the condition and appearance of the eye after the operation will probably not be better than before. If, however, it has encroached upon the cornea, it is better, as a rule, to operate, because, as has been said, it usually advances farther and farther upon this membrane, and, as it does so, it produces such changes in its structure as to leave behind a permanent opacity, even when the growth is most carefully removed. Patients will frequently assure the surgeon that the pterygium is not growing, and that for months or years it has made no progress; but their testimony upon this point is not always to be relied upon, and to prevent the possibility of the sight eventually becoming impaired, unnecessary delay in resorting to operation should be avoided.

The operative procedures which have been suggested for the cure of pterygium are numerous. Until a comparatively recent period, excision was the only operation which was in vogue. The results obtained by this method were, however, by no means uniformly successful, the removal of the growth, as it was commonly practised, being not infrequently followed by its recurrence. In consequence of this, various substitutes for this operation were proposed. For example, Des Marres suggested transplantation of the pterygium; Szokalski its destruction by strangulation, while Knapp introduced a modification of the former, and Galezowski of the latter, procedure. Pagenstecher recommended that the growth should simply be dissected from its corneal, and in part from its sclerotic, attachments, and then be allowed to atrophy, the edges of the conjunctival wound being united beneath the partially detached pterygium by means of sutures. Arlt, also, preferred a method essentially the same as that of Pagenstecher. In Des Marres's operation the pterygium is detached from the cornea and sclerotic quite up to its base, and is then inserted into an incision made in the conjunctiva near the lower edge of the cornea, where it is retained by sutures. Knapp's modification of this method, applicable to cases in which the pterygium is of large size, consists in splitting the pterygium longitudinally, after having removed its corneal portion, and inserting the upper half in an incision made in the conjunctiva above its base, and the lower half in one made below. He also unites the edges of the conjunctival wound by sutures, and, to facilitate this, separates the conjunctiva from the subjacent tissue above and below the wound. In Szokalski's operation the strangulation is accomplished by passing two needles, which have been threaded with the opposite ends of a fine silk ligature, beneath the pterygium, one near its apex, the other near its base, and then, after cutting out the needles, by tying together the ends of the three threads which are thus left in position, so as to cut off its vascular supply near its base, near its apex, and from its sclerotic surface. Galezowski, after dissecting up the pterygium, "takes a thread, armed at each end with a curved needle, and pierces the apex with both needles, so as to include it in a small loop. Then turning the needles inward, he brings them out at the base of the growth, one near the upper and the other near the lower margin. The two ends are then tied in a tight knot, and thus the apex of the pterygium is turned inward toward the base, and the latter is strangulated by the knot." It is claimed for each of these procedures that a recurrence of the growth is less apt to happen than when simple excision is practised.

The operation of excision has, in the writer's experience, yielded such satisfactory results that he has not been tempted to make trial of any of these newer methods. The end which they all accomplish seems to him to be the same—to minimize the loss of conjunctival tissue, and this is, undoubtedly, a most important thing; but, if the excision be performed as it should be, the loss of tissue is insignificant. Although the ill effects of a too free excision of the growth were long ago pointed out, especially by Scarpa, the writer is inclined to think that the poor results which many have obtained from this operation are due to unnecessary loss of conjunctival tissue. Even when but little more than the apex of the growth is removed, the gap which is left in the conjunctiva is of considerable size, and when the whole pterygium is cut off, the size of the gap which results, owing to the retraction of the conjunctiva, is surprising. Under such circumstances the healing process is slow and difficult, and ultimately a prominent vascular cicatrix is apt to be left, which is as unsightly, and as likely to cause trouble, as the pterygium itself.

Since the employment of cocaine in ophthalmic surgery the removal of pterygium has been rendered much easier, as the operation is now entirely painless. The method of operating which the writer has adopted, and which, as has been said, has yielded satisfactory results, being very rarely followed by a return of the pterygium, is as follows: The eye having been brought under the influence of cocaine, and the patient being seated in a chair, the operator standing behind, a stop-speculum is introduced. The growth is then seized near its apex with forceps, and with an iridectomy-knife, which is but slightly bent, is cleanly dissected from the cornea, especial care being taken to detach its margins from the corneal limbus. Its more loose attachments to the sclerotic are also separated for a short distance (2 or 3 mm.) from the corneal margin. Then, with a pair of slender scissors, curved on the flat, the whole of the corneal and a very small part of the conjunctival portion of the growth is removed at a single cut. If decided traction is made with the forceps upon the detached portion of the growth while the scissors are being used, and if the latter are pressed

against the sclerotic, a very much larger piece of the pterygium will be removed than is desirable. Only very slight traction, therefore, should be exerted, and in using the scissors (the points of which should be turned toward the base of the growth) it should be borne in mind that we are more apt to remove too much than too little tissue. A single stitch of fine black silk will suffice to close the conjunctival wound, and, unless more tissue has been sacrificed than is necessary, will bring its edges together without undue traction. The closure of the wound in this way hastens the healing process, and the removal of the stitch, on the second or third day, as may seem more desirable, can be accomplished without pain by the instillation of a drop or two of cocaine. The dressing most acceptable to the eye is a linen cloth wet with cold water, which may be applied at intervals for a few days. A collyrium of boracic acid (gr. v.-x. to aq. destill., ℥ j.) should then be prescribed, to be used three or four times a day, as it soothes the eye, lessens the secretion, and helps to subdue the inflammation. Should there be much ciliary irritation from inflammation of the corneal tissue, atropine is indicated, while, on the other hand, if there is considerable conjunctival secretion, without ciliary irritation, a very little sulphate of zinc (gr. $\frac{1}{4}$–$\frac{1}{2}$ to ℥ j.) or alum (gr. ss.–j. to ℥ j.) may be added, with benefit, to the boracic-acid solution. The patient should be warned that the improvement in the appearance of the eye will be slow, else he may suppose the operation has not been successful, and may mistake the vascularity which remains for some time about the former site of the pterygium for a return of the growth. When the pterygium has encroached upon the cornea, he should also be made to understand that after its removal a more or less perceptible opacity will remain upon the surface of this membrane. Should this opacity involve the central portion of the cornea, which in exceptional instances is the case, an iridectomy may be necessary in order to obtain a pupil behind a part of the cornea which is clear.

Samuel Theobald.

[1] W. Lawrence: Diseases of the Eye, p. 320. London, 1844.
[2] Ibid., p. 317.

PTOMAÏNES—POST-MORTEM ALKALOIDS. HISTORICAL.—The name *Ptomaïne*, written by some recent German authors *Ptomatine* (πτῶμα = that which is fallen, a corpse), was first suggested by Selmi, in 1875, to designate substances obtained from putrefying organic material and possessed of the general properties which characterize the vegetable alkaloids, and which were formerly considered as peculiar to those substances.

It had been observed in the first half of the last century that certain articles of food, when in a condition of incipient putrefaction, not sufficiently advanced to awaken suspicion by the liberation of odorous products, caused violent symptoms of poisoning and death in the human subject. It was also a matter of early experience that serious results, and even death, might follow inoculation with the juices of the uninjected cadaver before putrefaction had progressed to the stage in which putrid gases are given off.

The earlier observers advanced different theories concerning the nature of the poisonous substances in these cases. The earliest of these (1789) accounted for the poisoning by the supposition of an admixture of mineral poison. Emmert (1815) sought to show the formation of hydrocyanic acid during modified putrefaction. Rumpelt, Berres, and Saladin considered the poisonous qualities of certain sausages to be due to the formation of empyreumatic products related to creasote. The poisonous qualities of sausages were attributed by Boullay to the use of poisonous vegetables by mistake for the herbs commonly employed in their manufacture, and by Wunderlich to a diseased condition of the animals which yielded the meat. Kerner (1820) considered that picric acid (Welther's bitter) was the poisonous agent. Witting, Kerner, and Buchner thought it was a product of decomposition of the fats, an empyreumatic fatty acid, or acroleïn. Weiss and Liebig (1824) considered that the poison acted chemically upon the blood "by catalysis," and was "analogous to the typhic miasm."

The first to suggest the probability of the formation of an alkaloidal poison during putrefaction seems to have been Kastner (*Arch. f. Gesam. Naturlehre*, Bd. i. (1824), 448, 488; Bd. ii., 499), who advanced the hypothesis that poisonous sausages contained an "alkaloid of decay" (*Moderalkaloid*) combined with an organic acid.

In 1852, Schlossberger, in an exhaustive paper upon the sausage-poison (*Arch. f. Physiol. Heilk.*, Ergänz hft., 1852) supposes "the poisonous substances occurring in sausages and cheese to be organic bases, which have their origin in the decomposition (*Entmischung*) of the proteïn materials rich in nitrogen, under certain conditions." He supports this hypothesis by the following observations: 1st, When ammonia is produced in considerable amount by the decomposition of animal or vegetable substances, it is accompanied by volatile bases (Stenhouse); 2d, by the action of dilute potash upon poisonous sausages, much ammonia, "accompanied by a peculiar, repulsive odor," is given off; 3d, the physiological action of the putrid poison is very similar to those of the then known volatile alkaloids nicotine, coniïne, sparteïne, and to those of the artificial amide, imide, and nitrile bases of Hofmann; 4th, one of these bases, trimethylamine, is contained in herring-pickle. Schlossberger also suggests that fixed as well as volatile alkaloids are probably produced during putrefaction.

Four years later (1856) Panum was probably the first to isolate ptomaïne, in an impure state however (*Bibl. for Laeger*, 1856; *Schmidt's Jahrb.*, 1859, ci., 213; *Virchow's Arch.*, 1874, lx., 328–352). This substance was designated by Panum as the "extractive putrid poison." It is described as being soluble in water, from which it is precipitated by alcohol; capable of extraction from putrid meat; and not identical with known odorous products of putrefaction. It is capable of withstanding a boiling temperature, evaporation, and the influence of absolute alcohol—conditions inconsistent with the presence of lower organisms. Panum further states that it is comparable to the poison of serpents, curare, and the vegetable alkaloids in its action on the economy.

During the years 1859 to 1868, the subject appears to have remained in the condition in which it was left by Panum, although, in 1866, Hemmer, Schwenninger, and Von Raison published dissertations upon the putrid poison. In the same year, Bence Jones and Dupré obtained from animal matter a substance which formed precipitates with the general reagents for the alkaloids then known, and whose solution exhibited a blue fluorescence. To this substance they gave the name of "animal chinoidine."

In 1868, Bergmann and Schmiedeberg obtained a small quantity of a crystalline substance, which was poisonous to dogs and frogs, and to which the name *sepsine* was applied.

In 1869, Zuelzer and Sonnenschein obtained from cadavers a crystalline substance having physiological actions similar to those of atropine.

The discovery in cadaveric matter of alkaloids which could not be identified with any then known led Selmi to a series of experiments which enabled him to identify and characterize those ptomaïnes with greater precision. His first publication upon the subject was a paper read before the Academy of Sciences of Bologna, January 25, 1872. Since that time the contributions of Selmi and of his followers—Morrigia and Battistini, Trottarelli, Raffaele, Ziino, Albertoni and Lussana, Paterno, Spica, Brugnatelli and Zenoni, Bocci, Guareschi and Mosso, and Monari—have been voluminous and important.

Attempts have been made by Arm. Gautier and his followers to appropriate the credit due to Selmi (Gautier: "Ptomaïnes," p. 6, Paris, 1886), on the strength of unpublished experiments and a vague statement made in a work printed in 1874.

The most important of the numerous recent monographs upon this subject are those of L. Brieger ("Ueber Ptomaïne," i., 1885; ii., 1885; iii., 1886).

Nencki ("Ü. d. Zersetz d. Gelatine," etc., Bern., 1876) was the first to determine the chemical composition of a ptomaïne, and thus clearly to establish the nature and relations of these substances.

PTOMAÏNES FORMED DURING PUTREFACTION OF MUSCULAR TISSUE AND INTERNAL ORGANS OF MAMMALS.—*Cadaveric Alkaloids.*—The nature of these bases varies with those conditions which have been known to modify the progress of putrefactive changes, viz.: 1, the nature of the putrefactive ferment—*i.e.*, according to existing views, the species of bacterium; 2, the kind of albuminoid or gelatinoid undergoing putrefaction; 3, the temperature; 4, the degree of moisture; 5, the access, or non-access, of atmospheric oxygen.

In the case of cadaveric putrefaction, as it usually occurs, when the entire body is subjected to decomposition, it is also probable that the nature of the ptomaïnes produced is influenced by the results of the simultaneous changes which the carbohydrate and fatty constituents undergo.

As the process of putrefaction is gradual and progressive, different basic substances are produced at different stages. Therefore, a base obtainable in considerable amount from a body during the first days of putrefaction will have more or less completely disappeared at a later stage, when other bases, not previously present, will have made their appearance.

For our present knowledge of the composition of the cadaveric alkaloids we are largely indebted to Brieger (*loc. cit.*).

The numerous substances whose reactions and physiological properties have been described by Selmi and his followers probably consisted, in most cases, of the alkaloids mentioned below, mixed with greater or less quantities of other substances, or of their more or less pure products of decomposition. The frequent variations in chemical and physiological action of the materials operated upon by these observers are due to the fact that they consisted of residues whose purity was not assured by crystalline form or by chemical analysis. It is also probable that the number of existent ptomaïnes is by no means as great as an examination of the literature of the subject would lead one to suppose, although it is certain that many more will be added to those whose composition and character have been already determined.

Immediately after death the most unstable of the constituents of the body, *lecithin*, is decomposed into distearylglycerophosphoric acid and choline.

Choline, $C_5H_{15}NO_2$, is a syrupy, highly alkaline liquid, soluble in all proportions in water, whose chloride crystallizes in colorless, highly deliquescent needles, very soluble in water. With platinic chloride it forms a readily soluble double salt, crystallizing in orange-red prisms. With auric chloride it forms a crystalline double salt, almost insoluble in cold water, soluble in hot water.

This base was originally obtained by Strecker from ox-bile, in 1849, and was subsequently shown by Diakonow to be a constituent of *lecithin*. It was also obtained by Gobley from yolks of eggs, and has since been found to be widely disseminated in animal tissues. It has been considered by many chemists as identical with the *neurine* which constitutes a large portion of the protagon of Liebreich. The investigations of Baeyer, however, have shown that the two bases are distinct. *Choline*, obtainable from bile and lecithin, is identical with the synthetic trimethylhydroxethylene ammonium hydrate, $\left.\begin{matrix}(CH_3)_3\\(C_2H_4OH)\end{matrix}\right\}N,OH$, while *neurine* is trimethylvinyl ammonium hydrate, $\left.\begin{matrix}(CH_3)_3\\(C_2H_3)\end{matrix}\right\}N,OH$.

Choline is non-poisonous, except in large doses, which produce effects similar to those of muscarine.

As putrefaction advances, choline gradually disappears, its place being taken by trimethylamine, $(CH_3)_3N$, produced by its decomposition. After seven days, choline is no longer present.

Within three days after death another base makes its appearance:

Neuridine, $C_5H_{14}N_2$(?), a diamine discovered by Brieger. The chloride crystallizes in long needles, resembling urea, and is very soluble in water, insoluble in alcohol, ether, chloroform, petroleum-ether, benzol, and amyl-alcohol. If, however, it be accompanied by other animal substances, it is dissolved in greater or less quantity by the above solvents, and hence may be present in the extracts obtained by the Stas-Otto and Dragendorff methods. Solutions of the chloride give the following reactions with general reagents: Phosphotungstic acid, white, amorphous precipitate, soluble in excess; phosphomolybdic acid, white, crystalline precipitate; phosphoantimonic acid, white, flocculent precipitate; picric acid, precipitate, slowly converted into yellow needles; auric chloride, crystalline precipitate. With other usual reagents, nothing. With platinic chloride it forms flat needles of a double salt, readily soluble in water, from which solution it is precipitated by alcohol. The picrate is crystalline, and insoluble in water.

The free base is a gelatinous substance which decomposes even during evaporation of its solution. Its odor resembles that of spermatic fluid. It is insoluble in absolute alcohol and in ether, difficultly soluble in amyl-alcohol, readily soluble in water. It forms white precipitates with mercuric chloride, and with basic and neutral lead acetate. When heated with caustic soda it yields dimethylamine and trimethylamine, a decomposition which shows it to be not identical with amylendiamine, with which it is isomeric.

Neuridine is produced in greatest abundance in putrid intestines, while glandular organs yield but little under like conditions. It is no longer present after fourteen days. It is also found during putrefaction of fish, cheese, and gelatine, and is obtainable from fresh eggs and human brain-tissue.

When pure, neuridine is perfectly non-poisonous; but when contaminated by other putrefactive products it exerts a poisonous action.

On the third day of slow putrefaction, traces of another alkaloid are detectable, which increases in amount as the choline and neuridine disappear, and is accompanied by trimethylamine:

Cadaverine, $C_5H_{14}N_2$, a base identical with the pentamethylendiamine, $NH_2\text{–}CH_2\text{–}CH_2\text{–}CH_2\text{–}CH_2\text{–}CH_2\text{–}NH_2$, of Ladenburg, is a thick, transparent liquid, having a very disagreeable odor, somewhat resembling that of coniïne; boils at 175° C.; fumes, and absorbs carbon dioxide rapidly when exposed to air, being converted into a crystalline compound. Its chloride is crystalline, deliquescent, readily soluble in water and in dilute alcohol, but insoluble in absolute alcohol and in ether. With platinic chloride it forms crystals, resembling those of platinum-ammonium chloride, which are difficultly soluble in water.

The reactions of cadaverine chloride with the general reagents are as follows: Phosphotungstic acid, white precipitate, easily soluble in excess; phosphomolybdic acid, white, crystalline precipitate; bismuth-potassium iodide, red, crystalline needles; iodine in potassium iodide, or in hydriodic acid, brown crystals; picric acid, yellow needles; potassium chromate and sulphuric acid, red-brown, evanescent precipitate; ferric chloride and potassium ferricyanide, faint-blue color. The free base gives distinct blue with ferric chloride and ferricyanide.

Putrescine, $C_4H_{12}N_2$, is another base found by Brieger to accompany cadaverine. It is a clear, rather thin liquid of a disagreeable odor, resembling that of the pyridine bases; boils at 156°–157° C.; capable of distillation unchanged; absorbs carbon dioxide energetically from the air. Its chloride forms long, clear, transparent needles, is not hygroscopic, is readily soluble in water, sparingly soluble in dilute alcohol, and insoluble in absolute alcohol. The reactions of the chloride are: Phosphotungstic acid, white precipitate; phosphomolybdic acid, yellow precipitate; potassium iodhydrargyrate and bismuth-potassium iodide, amorphous precipitates, becoming crystalline; iodine in potassium iodide, or in hydriodic acid, brown, crystalline precipitates; picric acid, well-formed, broad, difficultly soluble needles. The

chloroplatinate of putrescine forms six-sided plates, as does also the chloraurate. Putrescine is not a homologue of cadaverine, but is probably either dimethylethylene-diamine or methylethylmethylenediamine.

Saprine, $C_5H_{16}N_2$, is still another base, formed under similar conditions with cadaverine, and distinguished from it by a greater solubility and different crystalline form of its chloroplatinate, by the absence of a compound with auric chloride, by the permanence of its chloride in air, and by its failure to give the reaction with potassium chromate and sulphuric acid.

Neither of the above-mentioned alkaloids is possessed of toxic qualities, with the exception of choline, and that only when administered in large quantity. It is probable that the poisonous effects produced by inoculation with cadaveric matter during the earlier days of putrefaction are due to substances such as the peptotoxine mentioned below and produced along with the peptones, which are among the first products of putrefaction.

Brieger obtained from human cadaveric matter two alkaloids possessed of actively poisonous qualities:

Mydaleïn, observed in small amount after seven days of free exposure to air, and increasing in amount up to three weeks. The amount of this base obtained was insufficient to determine its composition, further than that its chloroplatinate contains Pt., 38.74; C., 10.83; H., 3.23 per cent.; from which the inference is drawn that it is a diamine, closely related to the ptomaïnes above described. The chloride crystallizes with great difficulty, is very hygroscopic, and gives the following reactions: Platinic chloride, microscopic needles arranged in bundles; auric chloride, oily drops; phosphomolybdic acid, yellow, amorphous precipitate; phosphotungstic acid, white precipitate, soluble in excess; potassium iodhydrargyrate, yellow, oily drops; bismuth-potassium iodide, iodine in potassium iodide, and iodine in hydriodic acid, dirty-brown, oily drops; picric acid, a yellow oil; ferric chloride and potassium ferricyanide, immediate, intense blue color.

This alkaloid, administered to rabbits and guinea-pigs in very small quantity by hypodermic injection, produces the following effects: The lower lip becomes moist, the nasal and lachrymal secretions become very abundant, the pupils are dilated and insensible to light, the vessels of the ear are injected, the rectal temperature rises 1° to 2° C., the respiration and cardiac action are at first accelerated, the animal exhibits a tendency to sleep, and the peristaltic action of the intestines is augmented. The symptoms gradually abate and the animal recovers.

With larger doses (less than five milligrams=$\frac{8}{100}$ grain), administered to guinea-pigs, the action is intense and terminates in death. The secretion of organs provided with unstriped muscular fibres becomes very profuse. The pupils are widely dilated. There is exophthalmus. The animal falls; the posterior extremities being first paralyzed, then the anterior; and there occur fibrillar spasms of various groups of muscles. Sometimes the animal springs up and immediately falls, making faint motions of the legs. The body-temperature falls gradually; the movements become more and more faint, and the animal dies. The heart is arrested in diastole, and the intestines and bladder are found contracted after death.

Five milligrams of the chloride administered to a small cat caused death. There is immediate dilatation and insensibility of the pupils; the lachrymal secretion is very abundant. Profuse diarrhœa and vomiting of whitish masses follow. The secretion of saliva and perspiration become very profuse. The animal becomes lethargic, then suddenly springs up with accelerated respiration, and immediately sinks back. The secretion of alkaline, ropy saliva continues to increase. Violent convulsions occur. Soon the posterior extremities become paralyzed, afterward the anterior, while the abdominal and dorsal muscles contract spasmodically, and the animal lies with the head pressed down and the extremities extended. The respiration, at first very frequent, becomes slow and labored. The animal dies in a state of sopor. After death the heart is found to be arrested in diastole, and the intestine, whose mucous membrane is somewhat injected, contains a thin, fluid secretion.

By the putrefaction of muscular tissue in the presence of water, at the temperature of incubation, for five to six days, Brieger obtained, besides neuridine, an alkaloid possessed of distinctly poisonous characters:

Neurine, $C_5H_{13}NO$ = Trimethylvinyl ammonium hydrate, $\left.\begin{matrix}(CH_3)_3\\(C_2H_3)\end{matrix}\right\}$ N,OH (see choline, *supra*). A base whose chloroplatinate crystallizes in fine, well-defined octahedra, almost insoluble in water; and whose chloraurate crystallizes in flat prisms. Its chloride behaves with general reagents as follows: Phosphomolybdic acid, white, crystalline precipitate, insoluble in excess; phosphotungstic acid, nothing; phosphoantimonic acid, voluminous, white precipitate; potassium iodhydrargyrate, voluminous, yellowish-white precipitate; bismuth-potassium iodide, amorphous, red precipitate; cadmium-potassium iodide, white precipitate; iodine in potassium iodide, iodine in hydriodic acid, amorphous, brown precipitates; tannic acid, voluminous, dirty-white precipitate; mercuric chloride, granular, white precipitate.

When administered to frogs, mice, guinea-pigs, rabbits, and cats, hypodermically, the chloride of this alkaloid produces symptoms closely resembling those caused by muscarine. Cats are more susceptible to its action than the other mammals experimented on.

The administration of the poison to rabbits is soon followed by marked moisture of the nostrils and lips. Movements of mastication follow, accompanied by the discharge of copious, thick, tenacious fluid from the angles of the mouth. There is profuse secretion of saliva, which is at first thick and viscid, then thin and alkaline. The increased secretion of saliva continues until the termination of the poisoning, and varies in degree with the magnitude of the dose. Subsequently there is increased secretion from the Schneiderian mucous membrane and the lachrymal glands, the latter of short duration. The respiratory movements are at first more frequent and deeper than normal; the extraordinary respiratory muscles are brought into action, the head thrown back, and the nostrils dilated. These symptoms of dyspnœa alter in character as death approaches, in that the movements become irregular, superficial, and less frequent. The heart's action immediately after the injection is accelerated, so that the pulse cannot be counted. In a short time it becomes slower, and diminishes constantly in frequency. The pulsations are at first very strong, but subsequently become progressively weaker until the heart is arrested in complete diastole. The heart's action continues after cessation of respiration. Section of the vagi has no influence, and the heart responds to artificial stimuli. Occasionally contraction of the pupils occurs, an effect which almost always follows an application of a strong solution of the poison to the eye. Powerful peristalsis is an early symptom, causing an uninterrupted voiding of matters, at first consistent, subsequently watery. Ejaculation and dripping of urine also occur. If the abdomen be opened at this stage, tetanic contractions of greater or lesser portions of the intestine are seen. The spleen is also strongly contracted. Only when lethal doses are given do strong clonic convulsions occur, in which the animal soon dies. These convulsions are partially controlled by artificial respiration, but they soon recur. Locomotion is interfered with, the posterior extremities being first paralyzed, then the anterior, before the beginning of the convulsions. In cats there is an increased secretion of alkaline perspiration. Atropine is a powerful antidote; but atropinized animals are still subject to the action of the poison. When taken by the mouth this alkaloid produces the same effects as when administered hypodermically, but ten times the dose is required.

Mydine, $C_8H_{11}NO$, is a base obtained by Brieger from human cadaveric matter which had been in putrefaction four months at a temperature of +5° to −9° C. in closed vessels. The free alkaloid is strongly alkaline, has an ammoniacal odor, and is a strong reducing agent. Its chloroplatinate is very soluble.

Ptomaïnes.

From auric-chloride solution it precipitates metallic gold. Its picrate crystallizes in broad prisms, which fuse at 195° C. Its chloride gives a blue color with ferric chloride and potassium ferricyanide. It is non-poisonous.

From horse-flesh which had undergone four months' putrefaction, at a low temperature and without exposure to air, Brieger obtained three poisonous substances. One of these is a non-alkaloidal body, $C_7H_{17}NO_2$, probably an amido-acid, which acts upon frogs somewhat like curare. The other two are alkaloids.

Mydatoxine, $C_6H_{13}NO_2$. The free base is a strongly alkaline syrup, which crystallizes *in vacuo ;* insoluble in alcohol and ether ; decomposed by distillation. Its chloride is a colorless, thin syrup, which forms no double salt with auric chloride, and with platinic chloride a very soluble double salt, which fuses and is decomposed at 193° C.

Administered subcutaneously to guinea-pigs, the chloride of this base causes increase in the frequency of the respiration ; at first contraction, and later dilatation and insensibility, of the pupils ; and diminution of temperature, with short chills. Clonic convulsions, frequently of such intensity that the animal is involuntarily projected forward, recur at short intervals. The secretions of the salivary and lachrymal glands become more abundant. The body-temperature falls, and the respiration becomes less frequent. The ears, at first injected, become pale and cold. The extremities are paralyzed. The cardiac action becomes irregular and less frequent. Convulsions are provoked by striking upon the table supporting the animal. Shortly before death the convulsions become less strong, the extremities are extended, the animal falls upon its side and dies. After death the heart is found arrested in diastole, the intestines strongly contracted, and the bladder empty and contracted.

Methylguanidine, $C_2H_7N_3 = NH = C\begin{cases}NH(CH_3)\\ NH_2\end{cases} =$ *Methyluramine*, a colorless, highly hygroscopic, and strongly alkaline base, whose chloride crystallizes in prisms, insoluble in alcohol. The chloroplatinate crystallizes in very soluble needles. The picrate crystallizes in needles, which are sparingly soluble in water, and fuse at 192° C.

This substance is undoubtedly produced by an oxidation of creatin, to which it is closely related.

Methylguanidine is poisonous. Administered hypodermically to guinea-pigs, it causes copious diarrhœa and increased secretion of urine. The pupils are rapidly dilated and are insensible to light. The animal remains in one position, even when irritated. It soon becomes restless and seeks to move with the anterior extremities. The posterior extremities refuse to perform their function. The respiration becomes progressively deeper and more labored. The head is moved from side to side. The legs become paralyzed, and there is marked dyspnœa. The animal falls upon its side and dies, after short, general clonic convulsions. After death the heart is found in diastole, the intestine filled with fluid, the bladder contracted, the cortical portion of the kidneys hyperæmic, and the papillary portion pale.

Gautier and Étard have described two substances obtained from putrid meat, which they consider as identical with the pyridine bases *parvoline* and *hydrocollidine*, although their analyses do not accord closely with the amounts required by theory. The first of these alkaloids is an amber-colored oil, boiling at 200° C., sparingly soluble in water, and forming a very soluble chloroplatinate and a sparingly soluble chloraurate. The second is a colorless oil, having a penetrating odor, which becomes viscid and resinous when exposed to air ; absorbs carbonic acid ; boils at 210° C. Its chloraurate is soluble and readily decomposed ; its chloroplatinate, crystalline, pale-yellow, and sparingly soluble.

Ehrenberg (*Zeitschr. f. Physiol. Chem.*, 1887, xi., p. 239) obtained choline, neuridine, dimethylamine, and trimethylamine from sausages which had been the cause of serious poisoning of a number of persons, of whom three died.

Ptomaïnes from Putrid Fish.—Brieger, operating with the flesh of a species of cod (*Gadus callarias*) subjected to putrefaction with contact of air, obtained, besides neuridine, three ptomaïnes, two of which are actively poisonous :

A base, $C_2H_8N_2$, isomeric but not identical with ethylidendiamine, whose chloride crystallizes in long, brilliant needles, easily soluble in water, insoluble in absolute alcohol. It does not form a chloraurate. The chloroplatinate crystallizes in small, yellow scales, sparingly soluble in water. The chloride forms with phosphomolybdic acid a white precipitate ; with phosphoantimonic acid a yellowish-white precipitate, soluble in excess ; with bismuth-potassium iodide a red, crystalline precipitate. With other general reagents no precipitates are formed. The free base may be distilled from caustic soda without decomposition.

This base, administered hypodermically in small quantity to mice and guinea-pigs, produces in a short time increased secretions of the nasal mucus, saliva, and tears, which are subsequently temporarily arrested, to begin again later. The pupils are dilated and the globes protruded. There is marked dyspnœa, which continues until the death of the animal within twenty-four hours.

Muscarine, $C_5H_{15}NO_3$, identical with the alkaloid obtained from *Agaricus muscarius* and with that obtained synthetically from choline, forms a chloride which crystallizes with difficulty, and a chloroplatinate which crystallizes in octahedra.

This ptomaïne, administered in very small quantities to frogs, causes total paralysis and arrest of the heart in diastole. The administration of atropine to frogs under the influence of this base revives the action of the heart, and the effects of the ptomaïne are not observed in atropinized animals.

Minute doses, administered hypodermically to rabbits, cause greatly increased salivary and lachrymal secretions, contraction of the pupils, profuse diarrhœa, ejaculation, voiding of urine, and death after convulsions of short duration.

Gadinine, $C_7H_{17}NO_2$ (not to be confounded with the brown substance from cod-liver oil, to which De Jongh gave the same name), is a base whose chloroplatinate crystallizes in golden-yellow scales, sparingly soluble in water, and whose chloride crystallizes in thick, colorless needles, soluble in water, but insoluble in alcohol. No chloraurate exists. Crystalline precipitates are formed with phosphotungstic, phosphomolybdic, and picric acids. It appears to be non-poisonous.

Bocklisch obtained from putrid fish cadaverine, putrescine, neuridine, methylamine, trimethylamine, and ethylamine. The most abundant and uniformly present were cadaverine, putrescine, and methylamine. In the first stages, cadaverine was detected without putrescine, which subsequently exceeded the former alkaloid in amount. Large quantities of trimethylamine, accompanied by methylamine, are formed in the putrefaction of herrings. Both of these bodies have been long known to exist in herring-pickle. The same pickle also contains choline, which yields trimethylamine on decomposition.

Methylamine is the predominating base produced by the putrefaction of pike.

None of the bases isolated by Bocklisch is actively poisonous, although the extracts from which they were separated had markedly toxic powers.

Ptomaïnes from Cheese.—From cream-cheese which had undergone complete putrefaction, Brieger obtained neuridine and trimethylamine.

Vaughan (*Zeitschr. f. Physiol. Chem.*, x., 146) obtained from cheese, which had caused symptoms of poisoning, a crystalline substance which caused, when placed upon the tongue, a sharp, burning sensation, dryness of the throat, a sense of discomfort, and diarrhœa. This substance, whose composition was not determined, although the unusually constructed name *tyrotoxicon* was given it, produces a blue color with ferric chloride and potassium ferricyanide, and reduces hydriodic acid ; but it does not react with the general reagents for the alkaloids. It is readily soluble in water, alcohol, and ether.

PTOMAÏNES FROM PUTRID GELATINE.—Nencki, in 1876, was the first to determine the composition of an animal alkaloid. To the product which he obtained he gave the name of *collidine*, $C_8H_{11}N$. This base was produced by the decomposition of a mixture of gelatine, ox-pancreas, and water, during five days at 40° C. The free base is an oily substance, of a peculiar but not disagreeable odor, which absorbs carbonic acid from the air, to form scale-like crystals of a carbonate. The chloroplatinate crystallizes in fine, flat needles. Nencki considered this base as being isophenylethylamine, $C_6H_5—CH\langle^{CH_3}_{NH_2}$

Brieger subjected a strong solution of glue to putrefaction for ten days at 35° C. and obtained considerable quantities of neuridine, some dimethylamine, and a small quantity of a substance having a physiological action similar to that of muscarine.

PTOMAÏNES FROM POISONOUS MUSSELS.—In 1885 a number of cases of serious poisoning occurred at Wilhelmshaven in consequence of eating mussels (*Mytilus edulis*) (see below). From the fresh mollusks (living at the outset of the process) Brieger obtained, besides other bases, a poisonous alkaloid, to whose action their toxic qualities are due: *Mytilotoxine*, $C_6H_{15}NO_2$. The free base has a disagreeable odor, which it loses rapidly on exposure to air, and at the same time it becomes non-poisonous. It is decomposed on being heated with caustic potassa. Its chloride crystallizes in tetrahedra and is intensely poisonous, causing the same symptoms as the mussels. The chloraurate crystallizes in microscopic cubes, which fuse at 182° C. With the customary general reagents only oily precipitates are produced.

The remaining bases are non-poisonous, and consist chiefly of *betaïne=oxyneurine*, $C_5H_{11}NO_2$.

The poisonous mussels, when allowed to putrefy sixteen days, contain no poisonous base, but yield cadaverine, putrescine, and notable quantities of trimethylamine.

ALKALOIDS PRODUCED IN THE NORMAL LIVING BODY.—In 1849, Liebig obtained *creatinine*, $C_4H_7N_3O$, from the urine of the dog, and the same body was subsequently obtained by Pettenkofer from normal human urine, by Sokoloff from the urine of the calf, and by Valenciennes and Frémy from the muscular tissue of crustaceans. The occurrence, in the situations named, of this substance, which is alkaline in reaction, caustic, and capable of neutralizing acids, and of displacing ammonia from the ammoniacal salts, proves that an alkaloid may be produced in the normal living body.

It would seem probable that the rapidly lethal secretion of the poison-glands of certain serpents owes its activity to the presence of an alkaloid, yet the researches of Gautier (*Bull. Acad. d. Méd. d. Paris*, 2 Sér., x., 947) with the poison of the cobra capello (*Naja tripudians*) indicate that, although the secretion contains two relatively non-poisonous alkaloids, the most actively poisonous constituent of the venom is not alkaloidal in character, although it contains nitrogen.

From the poisonous secretion of the salamander (*Salamandra maculata*), however, Zalesky ("Med. Chem. Unt.," i., 85) obtained an alkaloid capable of producing effects similar to those caused by the secretion itself—anxiety, trembling, epileptiform convulsions, opisthotonos, and death. This alkaloid, *salamandrine*, $C_{34}H_{60}N_2O_5$, is amorphous, soluble in water and in alcohol, and strongly alkaline.

Gautier ("Ptomaïnes et Leucomaïnes," Paris, 1886) describes several bases as having been obtained from fresh beef and from Liebig's meat-extract. For these and similar substances produced in the body during life he has suggested the name *leucomaïnes* (λεύκωμα = white of egg), as indicating their probable origin from the albuminoids.

Xanthocreatine, $C_5H_{10}N_4O$, crystallizes in thin, sulphur-yellow, micaceous plates, resembling those of cholesterine in form, and greasy to the touch. Its taste is faintly bitter and, in quantity, it gives off a faint cadaveric odor. It is very soluble in water, and soluble in hot, strong alcohol. Its reaction is amphoteric. It resembles creatinine in its properties. Potassium iodhydrargyrate and iodine in potassium iodide cause no precipitates in the solutions, but phosphomolybdic acid causes a grumous, yellow precipitate.

"Xanthocreatine is poisonous in moderate dose. It causes depression, somnolence, extreme fatigue, defecations, and repeated vomitings in animals."

Crusocreatinine, $C_5H_8N_4O$, is a crystalline substance of an orange-yellow color, feebly alkaline, and slightly bitter, whose chloride and chloroplatinate crystallize in easily soluble needles, and whose chloraurate forms difficultly soluble granules, which are decomposed by heat. It also resembles creatinine in its properties.

Amphicreatine, $C_9H_{19}N_7O_4$, crystallizes in brilliant, oblique prisms of a yellowish-white color. It is tasteless and faintly basic. It resembles creatine in its properties.

Pseudoxanthine, $C_4H_5N_5O$, is a sulphur-yellow, crystalline body, resembling xanthine in its chemical and physical properties.

Besides the above, Gautier mentions two unnamed substances, $C_{11}H_{24}H_{10}O_5$ and $C_{12}H_{25}N_{11}O_5$, as obtained from normal muscular tissue.

These bodies are closely related to each other, and to creatine and creatinine; and the influence of the addition or removal of the group CHN in their formation is of interest, particularly when considered in connection with the recent discovery of a polymere of hydrocyanic acid, the *adenine* of Kossel.

Adenine (ἀδήν = a gland), $C_5H_5N_5$, is a basic substance, although neutral in reaction, obtained by Kossel (*Zeitsch. f. Physiol. Chem.*, 1886, x., p. 250) from the pancreas of the ox, and as a product of decomposition of nucleïn. It crystallizes in long needles, easily soluble in hot but difficultly soluble in cold water, insoluble in ether, chloroform, and alcohol. It forms well-defined salts with mineral acids. By the action of potassium nitrite it is converted into hypoxanthine, $C_5H_4N_4O$. When heated with caustic potash to 200° C. a large quantity of potassium cyanide is produced.

Urinary Alkaloids.—Besides creatinine, whose presence in normal urine is unquestioned, other alkaloids have been supposed to exist in that liquid. It has further been claimed (Picard, Schöltin, Oppler, Chalret, *et al.*) that the symptoms of uræmic poisoning are due, not so much to the retention of urea, as to the retention of certain toxic alkaloidal bodies included in the so-called extractive matters of the urine.

While it may be considered as probable that the urine under pathological conditions may contain alkaloidal substances, and even possible that such bodies may be produced in minute quantity by the normal organism, from which it is separated by the urine, the evidence in favor of such views is as yet entirely physiological and unsupported by isolation and identification of any supposed alkaloid.

Charrin and Roger (*Comptes Rendus Soc. d. Biol.*, iii., 607, Paris, 1886), experimenting upon rabbits, found human urine to be less poisonous to those animals than their own. The former in doses of forty cubic centimetres, in intravenous injection, causes punctiform contraction of the pupil immediately, exorbitism and injection of the vessels of the ear, followed by a semicomatose condition, sometimes interrupted by slight convulsive movements, in which the animal dies. With fifteen cubic centimetres of rabbit's urine there is neither exorbitism nor dilatation of the auricular vessels, but there are extremely violent tetanic convulsions. Immediately after death the heart is found arrested.

The authors consider that seventy-five to eighty per cent. of the toxicity of urine so administered is due to the action of the potassium salts. While the potassium salts are unquestionably poisonous, and therefore may be justly credited with a considerable share in the toxic effects of urine, their action does not correspond closely with the symptoms described; and the differences between the action of urines of different animals would seem to indicate the existence in them of different poisons, whether they be or be not alkaloidal.

Peptic Alkaloids.—The actively poisonous effects pro-

duced by inoculation with recent cadaveric matter cannot be ascribed to any of the alkaloids above mentioned, as those which are produced during the earlier stages of putrefaction are either non-poisonous or only slightly toxic, the actively poisonous alkaloids being only produced at a later stage.

One of the earliest products of putrefaction is a substance seemingly identical with the peptone produced by the action of pepsin or trypsin upon albuminoids, and formed, probably, in cadaveric matter in a similar manner by false ferments, similar to those of the gastric and pancreatic secretions existing in the animal tissues. As it has been shown by numerous experiments (Schmidt-Mühlheim, Hoffmeister, Faus, *et al.*) that a solution of peptone, when injected into the circulation, causes violent symptoms of poisoning, the supposition that the poisonous qualities of recent cadaveric matter is due to peptone, or to some substance formed at the same time with peptone, is not strained.

Indeed, Brieger (*loc. cit.*, i., 14) has separated from peptone, produced by the action of pepsin from the pig upon fresh fibrin, a substance (or mixture of substances) whose composition was not determined, but which presents some of the characters of the alkaloids, and to which the name *peptotoxine* was given.

This substance, which is actively poisonous in minute doses, crystallizes with difficulty, passes from both acid and alkaline aqueous solutions into amylic alcohol, is insoluble in ether, benzol, and chloroform, and very soluble in water. It is quite stable, and is not decomposed by boiling, or by treatment with sulphuretted hydrogen or with caustic alkalies. Its solutions are neutral. With Millon's reagent it gives a white precipitate, which turns bright red on the application of heat. Its solutions form precipitates with phosphomolybdic acid, phosphotungstic acid, cadmium-potassium iodide, potassium iodhydrargyrate, cadmium-bismuth iodide, auric chloride, mercuric chloride, iodine in potassium iodide, and iodine in hydriodic acid. With potassium ferricyanide and ferric chloride it forms Prussian blue.

The same substance was obtained from Witte's peptone, and from putrefying fibrin, caseïn, brain, liver, and muscular tissues. If putrefaction has lasted eight days it is no longer obtainable.

PATHOGENIC PTOMAÏNES.—Spica, in 1880 (*Gaz. Chim.*, x., 492), seems to have been the first to have obtained a ptomaïne from a pathological product during life.

As albuminoid substances, under process of putrefaction after death, produce alkaloidal substances, some of which are non-poisonous, while others are actively toxic, it seemed probable at an early period of the history of the ptomaïnes that the same or similar substances might be produced during life, and that, if produced, they might be the causes of certain pathological manifestations.

The researches of Koch and his followers have brought to light a number of well-defined pathogenic bacteria, the method of whose action seemed to be the most readily accounted for on the hypothesis that alkaloids or other poisons are produced during the processes of nutrition of these minute organisms. This view was strengthened by the observation of Passet (*Fortschritte d. Medicin,* iii.), that eight varieties of bacteria, cultivated from pus, were capable of producing lactic fermentation in sterilized milk; as well as by that of Brieger, that the pneumococcus of Friedländer and Frobenius is capable of producing formic and acetic acids and alcohol from carbohydrates.

Within the past two years the labors of Nicati and Rietsch, Pouchet, Villiers, and Brieger, have resulted in the separation and identification of several poisonous alkaloids from nutrient material in which pathogenic bacteria had been cultivated, as well as from the tissues and dejections of patients suffering from cholera and other diseases.

Ptomaïne of Asiatic Cholera.—Villiers (*Journ. d. Pharm. et d. Chimie*, 1885, Sér. 5, xi., p. 257) isolated 0.02 gramme of the chloride of a well-defined alkaloid from the internal organs of two cholera-patients. This base as well as its salts gave the following reactions: Potassium iodhydrargyrate, white precipitate; iodine in potassium iodide, brown precipitate; bromine-water and picric acid, yellow precipitate; auric chloride, light-yellow precipitate; tannin and mercuric chloride, white precipitates from concentrated solutions; platinic chloride and potassium dichromate, nothing; ferric chloride and potassium ferricyanide gave a blue color only after a time; sulphuric acid, a faint violet color, which soon disappeared. A guinea-pig which received 0.006 gramme of the alkaloid was seized in forty-five minutes with violent trembling of the anterior extremities, soon extending to the posterior also, and then diminishing and disappearing. The animal refused food for four days, when it died suddenly.

Nicati and Rietsch (*Journ. d. Pharm. et d. Chimie*, 1885, Sér. 5, xii., p. 292) obtained a fluid alkaloid by the Stas method from cultures of the comma bacillus. This base is volatile at 100°, and produces the same physiological action as the cultures. They obtained an identical substance from the blood and liver, removed two hours after death, from the body of one who had died suddenly in the algid stage of cholera. The same authors (*loc. cit.*, p. 385), in repeating their experiments under varying conditions, found the poisonous alkaloid to be produced in greatest amount at 35° after about ten days.

Pouchet (*Comptes Rendus*, c., 220–222; ci., 510, 511) isolated from the watery and almost colorless fæces of a cholera-patient an oily alkaloid, soluble in chloroform, possessed of the odor of the pyridine bases. It responds to the general reagents for alkaloids, and energetically reduces potassium ferricyanide, auric chloride, and platinic chloride. Its chloride is easily dissociated by heat or *in vacuo*. It produces actively poisonous effects, even when its vapor is inhaled. Traces of the same substance were found in the nutrient material of Koch's microbes.

Ptomaïne of Typhus.—Brieger ("Ptomaïne," ii., 68; iii., 85) obtained a base from cultures of the Koch-Eberth typhus bacillus in meat at a temperature of 37.5° to 38° C. for eight to fourteen days. This alkaloid has the composition $C_7H_{17}NO_2$, and has been named *typhotoxine*. The chloride is hygroscopic, forms an easily soluble chloroplatinate, crystallizing in needles; also a difficultly soluble chloraurate, crystallizing in prisms, which fuse at 176° C., and a difficultly soluble picrate. With reagents it behaves as follows: Phosphomolybdic acid, yellow, crystalline precipitate; phosphotungstic acid, white, crystalline precipitate; potassium-cadmium iodide, potassium iodhydrargyrate, iodine in potassium iodide, iodine in hydriodic acid, oily, non-crystalline precipitates; bismuth-potassium iodide, resinous precipitate. With Ehrlich's reagent (sulphodiazobenzol) it gives an immediate yellow color, which disappears on addition of a base. In cultures from which no typhotoxine is obtained there is much creatine or creatinine, while in those giving the best yield of the alkaloid the normal constituent of the meat is present in less amount. In bouillon, to which three per cent. of glycogen is added, the bacilli grow luxuriantly, without any decomposition of the glycogen.

This alkaloid causes a moderate increase in the flow of saliva and an acceleration of respiration. Later the animals lose control of the muscles of the extremities, without suffering true paralysis; they fall upon the side, and, if placed upon their feet, fall back helpless after a few steps forward. The pupils gradually dilate widely and become insensible. Convulsions do not occur. The frequency of the heart's action and the respiration gradually diminish. During the entire poisoning there is copious diarrhœa. After death the heart is always found contracted in systole, the lungs are highly hyperæmic, the other organs pale. The intestines are always strongly contracted, and their walls pale.

Ptomaïnes of Tetanus.—Brieger ("Ptomaïne," iii., 89; "Ber. d. Deutsch. Chem. Gesell.," xix., p. 3119) experimented with cultures of an anaërobe bacillus found by Nicolaier in earth-samples and capable of producing symptoms of traumatic tetanus in animals, and with cult-

ures of the same bacillus bred by Rosenbach from the wound of a man who died of tetanus. Two alkaloids endowed with similar physiological action were obtained.

One of these bases, *tetanine*, $C_{13}H_{30}N_2O_4$, is produced along with much ammonia. It forms a very soluble chloroplatinate, which crystallizes from alcohol in beautiful, light-yellow plates. The chloride is deliquescent and forms an easily soluble, crystalline compound with phosphomolybdic acid. With bismuth-potassium iodide it forms an amorphous precipitate, which soon becomes crystalline. The free base is a yellow, strongly alkaline syrup, which gives no blue color with ferric chloride and potassium ferricyanide.

The free base or its chloride, injected into mice or guinea-pigs, soon causes clonic or tonic convulsions of the greatest intensity, which terminate in death. The course of the poisoning is divisible into two stages. In the first the animal is depressed and lethargic, then it becomes suddenly uneasy and the diaphragm contracts energetically. The second stage is marked by convulsions, usually tonic, but occasionally clonic. Death occurs frequently in a violent convulsion. Frogs withstand the poison relatively better than warm-blooded animals, but when they succumb they become perfectly rigid in a position of pronounced opisthotonos. Guinea-pigs, when thoroughly under the influence of the alkaloid, exhibit very clearly the characteristic spasms of tetanus in the human subject and marked opisthotonos.

The other tetanizing ptomaïne has the composition $C_6H_{11}N$, and is a volatile substance, boiling at 100° C. In relatively large doses it produces in animals fibrillar contractions of diverse groups of muscles, particularly those of the neck and face. Motion is more and more interfered with until paralysis is established. Convulsions increase in intensity, attacking groups of muscles very violently. The animal lies with head thrown back and extremities extended, and, when pressed upon, makes movements as in swimming. Finally the animal falls upon its side and dies in a violent convulsion.

Chemico-Legal Considerations.—As the ptomaïnes, both those produced during putrefaction and those occurring as the products of pathogenic bacteria (the *toxines* of Brieger), as well as the so-called leucomaïnes, are true alkaloids, and as such are members of the same chemical group (function) as the vegetable alkaloids, the possibility that one of the former may be mistaken for one of the latter in a chemico-legal examination of a cadaver is obvious.

That such errors have actually occurred there can be no doubt. Three such cases are classical, and intimately connected with the history of the ptomaïnes. In the case of General Gibbone, who died in Rome under circumstances which awakened a suspicion of poisoning, two chemists who analyzed portions of the body were led to believe that death had been caused by *delphinine*. Upon a more careful examination, Selmi showed that the alkaloid obtained from the body of the deceased did not respond to several of the reactions of delphinine, and that it was not that alkaloid, but a ptomaïne ; which was also shown, by Ciaccia and Vella, to differ from delphinine in that it caused arrest of the heart in systole, whereas in poisoning by the vegetable alkaloid the heart is arrested in diastole.

In the case of the widow Sonzogno, who died in Cremona in 1873, the body was exhumed twelve days after death, and the experts who made the analysis testified upon the first trial, at Brescia, to having detected the presence of morphine, while three other experts considered it probable that the substance isolated was a ptomaïne. Selmi, to whom the matter was referred, showed conclusively, by an examination of the chemical and physiological properties of the isolated alkaloid, that it was not morphine, but a ptomaïne.

In the Brandes-Krebs case, tried in Brunswick in 1874, the two chemists who made the analysis claimed to have detected, besides arsenic, coniïne. Otto, in a revision of the work, showed that the substance considered as coniïne, although very similar to that alkaloid and to nicotine, could not be identical with either alkaloid or with any other known vegetable base.

The occurrence of mistakes like those mentioned, and the possibility of their recurrence, for a time cast doubts on the reliability of the tests for the vegetable alkaloids, and even formed an apparent foundation for the claim, on the part of defending counsel in cases of trial for alkaloidal poisoning, that all analytical results in such cases are unreliable and illusory.

Although this extreme view is not well founded, the existence of the ptomaïnes renders the work of the toxicologist most difficult in cases of alkaloidal poisoning, particularly if the alkaloid used be one of infrequent occurrence, and makes it incumbent upon him to exercise the greatest caution and deliberation before reaching a conclusion, which can only be arrived at with certainty after an exhaustive analysis with every known test.

Attempts have been made to devise some test or tests by which the ptomaïnes as a class might be differentiated from the vegetable alkaloids. No such reagent has been found, nor will it be. The ptomaïnes are as distinctly alkaloidal in their nature as the vegetable alkaloids, and are therefore possessed of all the characterizing properties of the group, and, consequently, any quality or reaction common to all ptomaïnes will be found to be possessed by the vegetable alkaloids as well. No reagent is known by which vegetable acids can be distinguished from those of animal origin, although such acids were among the earliest known organic compounds.

The principal reagents by which it has been claimed that the ptomaïnes might be distinguished from vegetable alkaloids are those of Brouardel and Boutmy,* and of Trotarelli.

The reaction of Brouardel and Boutmy consists in the formation of a blue color with ferric chloride and potassium ferricyanide, which, it was claimed, was brought about by the ptomaïnes, and not by the vegetable alkaloids. This reaction, due to the reduction of the ferricyanide to ferrocyanide and the formation of Prussian blue, is based upon the facility with which the ptomaïnes are oxidized and their consequent reducing action. There exist, however, ptomaïnes (see tetanine, *supra*) containing oxygen which fail to respond. On the other hand, any substance endowed with reducing powers exhibits the reaction, and among such substances are the vegetable alkaloids morphine, apomorphine, muscarine, aconitine, eserine, liquid hyoscyamine, amorphous ergotinine, atropine, and strychnine.

The reaction of Trotarelli consists in the addition of sodium nitroprusside and then paladium nitrate to the material under examination. With the ptomaïnes a play of colors is observed. The reaction is no more reliable to differentiate the ptomaïnes from the vegetable alkaloids than that of Brouardel and Boutmy.

Notwithstanding the failure of such reactions, it is possible to clearly establish the presence or absence of vegetable alkaloids without possibility of error due to the presence of ptomaïnes. No single reaction can be relied upon, even with alkaloids giving such marked reactions as strychnine and morphine. In cases of suspected poisoning the identity of the alkaloid should be established by *all* of its characters, chemical, physical, and physiological. Before applying the tests or determining the physiological and physical properties of the alkaloid under examination, it should be separated in a condition as nearly approaching purity as possible.

Many vegetable alkaloids resemble a corresponding ptomaïne in one or more of its characters, but a difference is found in others which will enable the two to be distinguished. Thus Wolkenhaar (*Correspondenzbl. d. Ver. Anal. Chem.*, i., 33, 37) describes a ptomaïne which resembles nicotine in that it is a yellowish liquid, turns brown in air, is completely volatile, and has the same odor, not disappearing on addition of oxalic acid, as nicotine, but differing from the alkaloid of tobacco in forming a non-crystallizable chloride and in failing to give Roussin's reaction with iodine in ethereal solution. In a case tried in Verona, Ciotto mistook for strychnine

* The reaction was first observed by Selmi, but was not considered by him as characteristic of ptomaïnes.

a ptomaïne which gave crystals with iodine in hydriodic acid, was reddened by hydriodic acid, and gave with potassium dichromate and sulphuric acid a yellow precipitate and a blue or violet color, although it was not bitter and had no tetanizing action. Brouardel and Boutmy (*Arch. d. Ph.*, Bd. 219, p. 462) met with a ptomaïne in a cadaver that had laid in water eighteen months, which closely resembled veratrine in that it was colored violet when warmed with sulphuric acid, brick-red with sulphuric acid and barium peroxide, and cherry-red when warmed with hydrochloric acid. It was distinguished from veratrine by the immediate reduction of ferricyanide and the absence of the characteristic muscular spasms caused by the vegetable alkaloid.

So far as known, no ptomaïne has been obtained which corresponds in *all* its characters with an alkaloid of vegetable origin, with the exception of muscarine. In a case of poisoning by that alkaloid its detection in the body after death could only serve as evidence confirmatory of that derived from an observation of the symptoms of muscarine-poisoning observed during life.

Sausage-Poisoning (*Allantiasis*, *Botulism*).—In the latter part of the last and the beginning of the present century there occurred in Würtemberg and the other states of Southwestern Germany numerous cases of serious and fatal poisoning, which were traceable to the ingestion of the different varieties of sausage which there form a staple article of diet. According to Buchner and Kerner, the first published record of a case of botulism is in the "Acta phys. med. Colleg. Med. Onoldini," 1735. Schlossberger estimates that, up to 1853, about four hundred such cases had occurred in the district mentioned, of which one hundred and fifty had terminated fatally.

Although it is certain that many, if not the great majority, of the older cases were not due to a poison, but to the then unrecognized trichina spiralis, well-defined cases of true botulism, with entire absence of trichinæ in either the sausages or the muscular tissue of the victim, have occurred in recent years, not only in Germany, but also in France, England, and the United States.

The poisonous sausages are always liver- or blood-sausages, or others of large size, smoked, and more or less softened in the interior. The central portion is in some cases of a grayish tinge, pulpy, and has a rancid or sharp and somewhat acid taste. The cortical portion is sometimes inert, while the central portion is actively poisonous. The odor is sometimes musty, but in most cases in no way peculiar. The odor of putrefaction is not observed.

It is highly probable that the poisonous character of such sausages is due to the formation in them of a ptomaïne, although efforts to isolate the alkaloid have not proved successful. Schlossberger obtained from poisonous sausages an ammonia having a nauseous odor, which he could not obtain from fresh ones (Maschka, *Handbuch d. Ger. M.*, ii., 514); and Ehrenberg obtained choline, neuridine, dimethylamine, and trimethylamine from a similar source (*Zeitschr. f. Physiol. Chem.*, xi., 239). None of these substances is, however, capable of causing symptoms resembling those of botulism, or possessed of sufficiently active poisonous qualities to account for the violent effects of the sausage-poison.

The action of the poison is usually manifested in from twelve to twenty-one hours after it has been taken, although Eichenberg (*Diss.*, *Göttingen*, 1880) mentions a case in which two to three hours elapsed, and Kaatzer (*Deutsch. Med. Wochenschr.*, 1881, vii.,) cites two cases in which the poisonous effects began in one hour. The recorded cases with a longer interval than twenty-four hours are probably cases of parasitic disease.

The total duration of the poisoning is very variable, as shown by the 48 cases cited by Müller (*Deutsche Klinik*, 1869, 1870), of which 6 died upon the first day, 19 from the second to the seventh day, 16 from the eighth to the tenth day, 4 from the eleventh to the twenty-first day, and 3 after long illness. Recovery is usually slow, and may require several months.

The earliest symptoms are usually gastric—nausea, abdominal pain, not intense, but increased on pressure; vomiting of yellow, pulpy, sour, or bitter masses, and, not infrequently, purging. These symptoms, which in light cases are sometimes the only ones observed, are never so intense as in cholera-morbus, and are never accompanied by the cyanosis and cramps which occur in poisoning by mussels, by certain varieties of fish, and by cheese.

Following upon the gastric symptoms, either immediately or after an interval of a day or more, or, in some cases, without the occurrence of gastric symptoms, the true poisonous action is established. The secretions are much diminished or arrested, the mouth, tongue, and pharynx are dry, and neither saliva, perspiration, nor tears are secreted. The skin is wrinkled and cool. The tongue is covered with a whitish coat, the buccal mucous membrane is marked with aphthous patches, and the pharynx is inflamed or ulcerated and coated with a grayish-white deposit. The voice is hoarse, and in some cases there is a dry cough. The urine seems to be the only secretion which is not diminished. The nerve-supply of the eye and ocular muscles is markedly interfered with. There is diminished vision, which may reach the point of temporary blindness; objects appear colored and sometimes double, and the field of vision is traversed by sparks. The muscles moving the globe are partially paralyzed and the pupil dilated. Paralysis of the levator palpebræ superioris, with consequent ptosis, is characteristic. Interference with deglutition is a marked and constant symptom, and is frequently accompanied by interference with the movements of the tongue and with hoarseness, or even aphonia.

Apart from the above symptoms, referable to paralysis of individual cranial nerves, the cerebral functions and those of the spinal nerves are but little interfered with. Consciousness is perfect, almost up to the time of death. The functions of the sensory nerves remain unimpaired. There is great and progressive muscular weakness, which is probably due rather to the same cause as the progressive emaciation which also occurs—*i.e.*, interference with nutrition by dysphagia or aphagia—than to any action upon the motor spinal nerves. The patient complains chiefly of the derangements of vision and of attacks of suffocation.

Death is caused in many cases by marasmus. In some cases suffocation, with or without preceding convulsions, is the cause of death; or sometimes suffocation due to entrance of particles of food into the air-passages.

The symptoms of botulism present some similarities to the action of certain poisons. The solanaceæ—belladonna, stramonium, and hyoscyamus, and the alkaloids obtained from them—produce not only dilatation of the pupil and paralysis of accommodation, but also marked dysphagia and diminution of the secretions. But they also produce cerebral symptoms—delirium and hallucinations—which are absent in botulism. Moreover, the pulse is much more rapid in poisoning by the solanaceæ than in botulism, and the course of the poisoning occupies much less time.

The similarity between botulism and poisoning by gelseminum or its alkaloid is still closer. The effects upon the eye and its muscles, including ptosis, are the same in the two forms of poisoning, which may, however, be readily distinguished by the much more rapid and, in cases of recovery, temporary action of the vegetable product.

In trichinosis the mydriasis and paralysis of accommodation which occur in botulism are of very rare occurrence, while the cerebral symptoms and sopor which are observed in the former do not occur in the latter. A positive diagnosis may be made after death, or even during life, by microscopic examination of the muscular tissue.

No characteristic post-mortem appearances are recognizable. The body is emaciated, and the skin bleached and parchment-like. Rigor mortis begins early and continues longer than usual, and putrefaction is delayed in some cases, but very rapid in others. The mucous membrane of the mouth and pharynx is often white, dry, and parchment-like, or horny. The gastric mucous

membrane is frequently injected and sometimes ecchymotic. The spleen is sometimes enlarged, congested, and extremely soft and friable. The blood, as a rule, is dark, and contains no foreign organisms or elements. The corpuscles are unaltered. The lungs are frequently congested and œdematous.

POISONOUS FISH.—Not only do fish become poisonous when putrid, but certain species are either always poisonous to the human subject or become so at times. In some cases the same fish, eaten with impunity by one person, proves actively poisonous to another.

Poisonous fish are usually the inhabitants of warm climates. Stuart Eldridge (*Med. Times and Gaz.*, 1879, ii., 377) mentions a Japanese fish, a species of Tetrodon, called by the natives *fugu*, whose use as food is interdicted by law. In three cases of poisoning by this fish, one of which terminated in death, the symptoms began in from fifteen to forty-five minutes. There were headache, nausea, great muscular weakness, failure of the pulse and respiration, diminution of temperature, and total insensibility.

James Edwards (*Brit. M. Journ.*, 1884, i., 10) records a case of poisoning in a man, aged sixty-eight, by the flesh of the ray. In fifteen minutes the face began to swell; there was a burning sensation in the hands and back of the head; the feet were cold; the tongue swelled until it filled the cavity of the mouth, causing a choking sensation at the root of the tongue; the eyes were swollen and protruded. The patient suffered no pain but great dyspnœa and thirst and an intense itching of the skin. Consciousness was perfect. The patient vomited freely and soon recovered.

The roe appears to be the most actively poisonous portion of the fish. Belin (*France Méd.*, ii., 1458, Paris, 1886) reports the poisoning of a man of thirty, caused by eating three roed herrings broiled; the symptoms being chiefly gastric, and very violent and persistent. The same author refers to cases reported by Goertz, in which three members of a family who ate fresh roed fish suffered violent symptoms, while the other members of the family who ate milt fish were not affected. Similar cases are reported by Münchmeir (*Berl. Klin. Wochschr.*, 1875, xii., 4) and Naunyn (*Schmidt's Jahrb.*, 1884, 113).

Remy (*Comptes Rendus Soc. Biol.*, 7 Sér., iv., 14, 263, Paris, 1883) also concludes that the ovaries are the seat of the poison in poisonous fish.

It seems probable that fish-poisonings are due to the formation, either normally or in a diseased condition of the animal, of alkaloidal substances similar to that obtained by Brieger from poisonous mussels (see above), although no such substance has as yet been isolated.

POISONOUS MUSSELS.—The edible mussel (*Mytilus edulis*) frequently becomes actively poisonous, probably by reason of changes in the character of the surrounding water A case is recorded (*Guy's Hosp. Rep.*, 1850, 213) in which serious symptoms and a scarlatinal eruption were caused by eating two mussels, and another (*Med. Times and Gaz.*, 1864, 496) in which similar effects followed the ingestion of a single mussel. Death has resulted in several instances (*Med. Times and Gaz.*, July 28, 1860; *Lancet*, 1873, i., pp. 247, 323; "Fodéré Méd. Lég.," iv., 85).

Farrar (*Brit. Med. Journ.*, 1882, i., 939) reports the case of a strong, temperate, well-built man of sixty who had been in the habit of eating mussels without ill effects. Immediately after eating about twenty, without removing the "moss," or byssus, he felt sick and had griping abdominal pain. In half an hour he vomited and purged severely five or six times. In two and a half hours he was in a state of extreme collapse. The hands and feet were cold; the radial pulse was almost imperceptible and much increased in frequency. The face was pale, except occasional hectic flushes on the cheeks, the nose white, pinched, and quite bloodless, the pupils normal, the tongue clean. There was loud wheezing and rattling respiration, with frequent yawning and sighing. The patient fainted frequently, in spite of large doses of brandy. There were repeated clonic spasms, apparently implicating all the muscles of the body. He was perfectly calm and conscious, suffering no pain but great thirst and itching over the entire surface. There was neither sense of constriction of the throat nor headache. Surrounding objects appeared misty. The chest was covered with a rash resembling erythema. The next morning recovery was complete.

It was found by Max Wolff (*Arch. f. Path. Anat.*, civ., 108, 202) that the mussels which caused the poisonings at Wilhelmshaven, in 1885, came from a basin containing stagnant water, which was also the habitat of a poisonous star-fish (*Asterias rubeus*); but that the mussels from the neighborhood of the sluices, where the water was changed, were not poisonous. Schmidtman and Virchow (*Arch. f. Path. Anat.*, civ., 161, 179) found that the poisonous mussels, when transplanted to pure sea-water, lost their poisonous qualities completely in from two to four weeks; while non-poisonous mussels became actively toxic after two to three weeks' sojourn in the stagnant water of the basin. The poisonous individuals have a somewhat lighter and more striped shell than such as are innocuous. As mentioned above, Brieger obtained a poisonous alkaloid from the poisonous mussels.

POISONOUS CHEESE, MILK, BREAD.—It occasionally happens that a single cheese, produced along with many others at a properly conducted factory, causes symptoms of violent, irritant poisoning in all who partake of it, without presenting any peculiarity of appearance, odor, or taste which would indicate its poisonous qualities to the human senses, although dogs and cats are able to distinguish the poisonous cheese from a sound one, apparently by the sense of smell.

In cheese-poisoning the symptoms are chiefly those of irritant poisoning—severe vomiting and purging, dizziness, and great prostration, beginning in from one to four hours. The pulse is feeble and irregular, and the face is markedly cyanosed. Although the symptoms are frequently very severe, no fatal case is recorded.

The poisonous constituent of such cheeses, the so-called tyrotoxicon of Vaughan (*vide supra*), may either be produced by incipient putrefactive changes in the cheese or may pre-exist in the milk of which it has been made.

Milk has been known to produce serious outbreaks of poisoning or disease. In many of these the injurious effects are to be attributed, not to the presence of any putrid alkaloid in the milk, but to adulteration with impure water. Thus, in an outbreak which occurred in Aberdeen, in April, 1881, and in which three hundred and twenty-two persons were affected and three died, the milk as taken from the cows was found to be perfectly good, while the water used in the dairy was dangerously contaminated with the same material as that found in the contaminated milk (Beveridge).

Moreover, the recent researches of Power and Klein, concerning an outbreak of scarlet fever in London, seem to show that the disease may be caused in the human subject by the use of milk obtained from cows suffering from a similar disorder.

But apart from such instance of disease-transferral, cases have occurred in which true poisoning has been caused by milk. Firth (*Lancet*, 1887, i., 213) describes the cases of ten soldiers confined in a military prison. Of these, one who took none of the milk in question was not affected. The other nine were seized with nausea, vomiting, dryness of the fauces, a sense of constriction of the throat, colic, purging, and a tendency to collapse in some, in others a tendency to stupor. All recovered. The milk was apparently of good quality. A portion was coagulated, filtered, rendered feebly alkaline with caustic potash, and agitated with ether. The ether on evaporation left a semi crystalline, moist residue, having a mawkish, sickly odor and a strongly pungent taste. This substance caused nausea, dryness of the fauces, and headache in the human subject, and purging and vomiting in a dog. Attempts to produce the same substance from milk kept at 80° F. were only successful after three months. Firth suggests the name *lactotoxine* for this substance. Is it identical with tyrotoxicon?

Cases of poisoning by articles of food into whose composition milk enters are of occasional occurrence. An interesting instance of this form of poisoning, indicating the influence of different degrees of heat upon the toxic substance, is reported by Allen (*Med. Times and Gaz.*, 1878, ii., 519; *Sanit. Rec.*, London, 1878, ix., 257). Two bread-puddings were made of bread-scraps, milk, eggs, sugar, nutmeg, and currants. One was baked in a quick oven and caused no untoward results; the other was baked in a slow oven and caused severe poisoning in all who partook of it, and two deaths. The symptoms were those of violent, irritant poisoning, with severe vomiting and purging, greatly accelerated pulse, and rapid unconsciousness. The pudding which caused the poisoning was fed to a six-weeks-old puppy and to mice without the production of any toxic effects. It was not bitter in taste, did not exhibit the reactions of ergotine, gave off an unmistakable odor of herrings (methylamine) with caustic soda, and the alkaline solution assumed a brilliant lake-red color on standing. When a slice of bread was soaked in milk and sugar, and a portion of the poisonous pudding placed at one end, the substance giving the above reaction was gradually produced throughout the bread.

R. A. Witthaus.

PUBERTY (Lat. *Pubertas*, from *pubeo*, *pubere*, to become mature, or fit for procreation). By this term is meant that period of life when the human being becomes fitted for reproduction, evidence of which is afforded by rapid development of the sexual organs; for hitherto these organs had grown little from the period of infancy, and no exercise of their function was possible. Besides, it is usual for accelerated growth of the whole body to take place at the same time, and in the male the voice undergoes change, becoming an octave lower in pitch, from enlargement of the vocal organs. During the progress of this change the voice is unsettled, and often varies in a single utterance from one to the other key. In both sexes the pubic region becomes clothed with a hairy growth, followed later by the same growth in the axillæ, and, in the male, by the beard. In the female, particularly, there is a rapid deposit of fat in the subcutaneous cellular tissue of the breast and extremities, producing that roundness of form which contributes so much to the accepted type of beauty, and the deficiency of which is so often supplied by art.

Along with these physical traits a marked change in *morale* takes place. The individual manifests instinctive consciousness of sexual maturity by newly awakened sensibilities toward individuals of the opposite sex, commonly of attraction, but sometimes of repulsion, or, rather, timidity and shyness. In the female, particularly, an air of decorum and dignity is assumed by those of well-balanced minds; while the ill-balanced become pert and forward. Boys, rather than girls, are apt to develop a lasting shyness of the opposite sex, greatly to their discomfort and disadvantage.

From this time in the male the testes, prostate, and Cowper's glands constantly produce their characteristic secretions, unless interrupted by special lesions, or by serious general disease. In the female the ovaries begin their regular function of discharging perfected ova into the uterus, repeated generally at intervals of four weeks, and attended with a sanguineous flux from this organ, which lasts normally for three or four days. This function of menstruation, except when suspended by pregnancy and lactation, should recur regularly throughout the reproductive life of woman, which usually embraces a period of from thirty to thirty-five years. The developed mammæ become capable of assuming their function, whenever called for by the wants of offspring.

In the female the condition of puberty is preceded, for a varying time and in a varying degree, by certain disturbances, due to the new determination of blood to the sexual organs. Among these, headache, backache, corporeal and mental lassitude, palpitation, hæmorrhage from the nose, the lungs, and the stomach, are most frequent, and such nervous deviations as result frequently in hysteria and sometimes temporary insanity. At this period in both sexes nutrition is at its highest activity, and hæmorrhages are remarkably well tolerated. An inherited proclivity to disease, particularly pulmonary consumption, is apt at this time to manifest itself.

The access of puberty commonly occurs at the age of from fourteen to sixteen years in the male, and a year earlier in the female, for the temperate regions of the world. Considerable variation is found, however, beyond these limits in both males and females. The researches of Thomas More Madden, in the British Isles, have resulted in the following table of 497 cases, quoted from Quain's "Dictionary of Medicine:"

Under	twelve	years	4	menstruated	for the first time.
At	"	"	17	"	" " " "
"	thirteen	"	50	"	" " " "
"	fourteen	"	94	"	" " " "
"	fifteen	"	138	"	" " " "
"	sixteen	"	105	"	" " " "
"	seventeen	"	65	"	" " " "
"	eighteen	"	10	"	" " " "
Over	"	"	14	"	" " " "

Puberty is generally admitted by good authorities to occur somewhat earlier in hot climates, and the prevalence of very early marriages in tropical regions has incorrectly led to an impression of correspondingly early puberty. Undoubtedly habits of idleness and luxury hasten it, as a life of severe labor, hardship, and privation tends to retard it. Late appearance of puberty sometimes results from ill-health, and is not the cause thereof, as is supposed by the laity. In such cases it is sufficient to treat the actual disease or condition. Whenever retarded menstruation coexists with good general health, with or without other signs of delayed puberty, no medical interference is called for.

Instances of abnormally early puberty are on record, and are quite compatible with good general health. In vol. xli. of the "Medico-Chirurgical Transactions" is a table of 13 cases reported by various medical writers, which is here presented:

Title of work.	Author's name.	Sex.		Age when menses appeared.
		M.	F.	
Philosoph. Trans., 1754, vol. xliii	Dr. Mead	1	.	....
Med.-Chir. Trans., vol. i	Mr. Anthony White	1	..	....
" " " " ii	Mr. Cooke	..	1	Never menstruated.
" " " " ii	Dr. Martin Wall	..	1	9 months.
" " " " iv	Sir Astley Cooper	..	1	3 years.
" " " " xi	Dr. G. Breschet	1		....
" " " " xii	Mr. South	1	..	....
Med. and Phys. Jour., vol. xxv	Dr. Cookson	..	1	3½ years.
Midland Med. Reporter, vol. i	Dr. Burne	1	..	....
Med. Gazette, 1832	Dr. Ledsean	..	1	3 years.
" " 1840	Dr. Peacock	..	1	Nearly 5 yrs.
North. Jour. Med., 1845; Taylor's Med. Jurispr.	Mr. Whitmore	..	1	A few days of age.
Lancet, 1848	Mr. Embling	..	1	2 years.

In the first of the above list the external signs of puberty (enlargement of the sexual organs) occurred at the age of twelve months. This child died in 1752, at the age of five years, of pulmonary consumption, having an appearance of premature senility.

The third case had the usual appearances of precocious maturity, except size, physiognomy, and intelligence. The mammæ began to enlarge at the age of eighteen months.

The fifth case, at four and one-half years, had the breasts as well developed as a woman of twenty years, and was very broad in the chest and loins. At six years she was 4 feet 1 inch in height, menstruated every three weeks, and had hair in the axillæ. A sister, then aged seventeen, had not yet menstruated.

The sixth case, at three years of age, was 3 feet 6¼ inches in height, and weighed 50 pounds; had enlarged generative organs, with frequent erections and seminal stains on his linen. The voice had changed in pitch.

The seventh case was unusually large at birth, with hair as long and abundant as is usually found at five

months, prominent pudenda, and a hoarse voice. At four months hair appeared on the pubes, the penis and testes began to enlarge, and at fifteen months the glans was entirely exposed. Seminal stains appeared soon after. At the age of three years and four months he was 3 feet 7 inches in height, and weighed 64 pounds. Length of penis, flaccid, 3 inches; erect, 6 inches.

Another case, not included in the above table, born in 1806, showed at twelve months of age a change of voice, enlargement of generative organs, and hair on the pubes. At three years he appeared physically mature, though without a beard. Height, 3 feet 4½ inches; weight, 51½ pounds; circumference of cranium, 20 inches; of waist, 24 inches.

The extreme sexual and general physical precocity of these cases was not attended with corresponding intellectual development, and the condition, as a whole, must be regarded as an unfortunate one.

Inasmuch as the period of puberty, especially with girls, is attended by an important change in the direction of the nutritive energies, and sometimes with alarming disturbances of the nervous functions, it is clear that the requirements of physical, and still more of mental, exertion should be carefully regulated. This has particular reference to school duties, which are apt to be unduly imposed by teachers, encouraged or prompted by the ambition of doting parents to witness and boast of scholastic attainments. The result is liable to be wreck of the nervous system, or prolonged nervous and muscular prostration.

The family physician is occasionally asked to relieve the painful or emotional phenomena of incipient puberty, or more frequently to bring on the menstrual flow. There is too great disposition on the part of mothers to request active medication. Sometimes it is required, but often a placebo is preferable. For headache the alkaline bromides are suitable, when there is evidence of determination of blood to the brain. Hysteria may call for valerian, asafœtida, or emetics. Persistent pain in the back would justify warm hip-baths, or even aloetic purging. In case of anæmia, quinine and iron would be indicated.

S. S. Herrick.

PUERPERAL CONDITION. The term puerperal, derived from two Latin words, *puer*, a child, and *parere*, to bear, strictly speaking, pertains to the condition or state of child bearing; but usage has restricted its application to that period succeeding parturition which commences with the completion of labor, and continues until the genital organs shall have recovered their normal condition. This restoration is usually accomplished in about six weeks, provided the processes of repair and involution are not interrupted by any complication, accident, or failure.

Certain constructive changes in the genital apparatus, incident to gestation and parturition, after fulfilling their several missions, must undergo destructive metamorphoses; traumatic lesions need to be healed; and the function of lactation is to be established or called into renewed activity.

Familiarity with the physiology of the puerperal state is essential, in order that any deviation from the line of normal progress may be promptly detected, and that dreaded pathological developments may be clearly recognized, intelligently combated, and, if possible, successfully resisted.

SHOCK.—Immediately succeeding labor, the woman experiences a sense of fatigue and more or less shock, sometimes verging upon exhaustion. The fatigue and shock are generally most marked after severe and protracted labors, and in very susceptible subjects.

Rest, and occasionally an opiate, is the appropriate treatment.

CHILL.—The so-called post-partum chill occurs in some cases. It follows closely the expulsion of the child, and usually lasts several minutes. It possesses no pathological significance. It is probably due to the sudden cessation of the violent muscular effort associated with the severe expulsive pains, during which the surface of the body is profusely bathed with perspiration and the superficial vessels are filled with blood. The sudden withdrawal of the pressure of the gravid uterus and the consequent determination of the blood to the abdominal veins, producing a temporary depletion of the cutaneous capillaries, has been suggested as a possible cause.

No treatment is required beyond an increased amount of covering. The sensation and shivering soon subside, and are not followed by appreciable reaction. The occurrence of the chill may, very properly, be anticipated by supplying additional covering to the patient immediately after the extrusion of the child.

AFTER-PAINS.—The more or less rhythmical contractions of the uterus which occur, notably in multiparous women, for a few hours after delivery, frequently give rise to pains, similar, but by no means so severe as those experienced during labor. These pains are called after-pains, and are present in inverse ratio to tonic uterine contraction. Incomplete contraction allows intrauterine hæmorrhage, and the resulting clots provoke expulsive efforts on the part of the uterus, which may be the cause of very acute pains. Pains may likewise be caused without hæmorrhage by the contractions which follow frequently recurring relaxation. The reflex influence produced by the application of the child to the breast may also cause these pains. The existence of this sympathetic relation is sometimes happily utilized to secure firm and continuous contraction. After-pains are rarely observed in primiparæ. They are seldom protracted beyond twenty-four to forty-eight hours.

The proper treatment consists in securing and maintaining tonic contraction of the uterus. External pressure and manipulation, and ergot, usually suffice to accomplish this result. Opiates may, in addition, occasionally be required, and Dr. Barker[1] recommends full doses of quinine and the application of stimulating liniments to the hypogastrium in certain obstinate forms, which he regards as neuralgic in character.

TEMPERATURE.—Before the termination of labor the temperature is increased one or two degrees above the normal standard. After a day or two it recedes to, or even below, the level of health, though transient elevations of temperature, are liable to occur throughout the puerperal period. The continued increase of more than two degrees, especially if it be accompanied by a rapid pulse, denotes some complication, and is a sufficient cause for anxiety.

Lusk[2] considers a rise of from a half to one degree for the first six days, with slight evening exacerbations, as normal, and he confirms the opinion of Schroeder, that a temperature of 100.5° F. belongs within physiological limits and, moreover, that a rise even above this is not incompatible with a generally satisfactory condition of the patient.

Barnes,[3] on the other hand, positively affirms that no important increase of temperature is observed in puerperal women under healthy individual and sanitary conditions. He repudiates the observations made in lying-in hospitals, which show a rise of over 0.5° F., and declares this cannot be accepted as normal.

A slight fall of temperature, sometimes noticed within twenty-four hours after labor, is soon followed by a return to the standard. The increased heat is attributed to oxidation of tissue in connection with involution of the uterus, to the small wounds generally present in the genital tract, and to disturbances associated with commencing lactation.

PULSE.—After labor the pulse usually falls from 90 or 100 to 60 or 50, and, in exceptional cases, even lower. This slow pulse may last from three to seven days, and is regarded as a favorable indication, while, on the contrary, a rapid pulse is deemed an omen of unwelcome import.

Various hypotheses have been advanced in explanation of this clinical fact. Some ascribe it to increased arterial tension in consequence of the sudden arrest of the circulation in the uterus; others to diminished arterial tension, and still others to the complete and grateful rest—the pervading calm which succeeds the storm.

LOCHIA.—The lochia is a term applied to the liquid waste discharged from the uterus after delivery. The flow generally continues, in diminishing quantity and changing quality, for two, three, or four weeks. Exceptionally it ceases after only a few days. At first it is composed principally of blood which oozes or flows from the placental site, and serves to wash away particles or shreds of membrane, clots, and some of the various products of degeneration. As the blood-corpuscles in the lochia gradually decrease, the appearance changes from red to a pale greenish or yellowish hue, and, finally, it resembles a clear, albuminous liquid.

The odor is peculiar and more or less offensive, though under normal circumstances it should never be putrefactive or indicative of organic decomposition. Not infrequently the flow is suspended for a few hours, or is greatly diminished about the time the secretion of milk commences. Early suppression is not regarded as necessarily a dangerous symptom, but its sudden subsidence may be associated with grave pathological complications. If fetor or suppression be accompanied by a quickened pulse and an elevated temperature, it may possess important significance, and it demands measures of treatment to be considered hereafter; otherwise, warm fomentations or turpentine stupes to the hypogastrium, or the warm vaginal douche, will usually suffice to restore it. A decidedly offensive odor requires for its correction antiseptic vaginal injections: about two drachms of carbolic acid to a pint of warm water, or a watery solution of the corrosive chloride of mercury—one part to two or three thousand parts—every eight, twelve, or twenty-four hours, is usually effective. Two or three pints of either solution may be used.

Of recent years antiseptic measures have been given a much more prominent position in the management of puerperal patients than formerly. Antiseptic vaginal injections are now recommended and employed by some obstetric practitioners in every case, and even uterine injections are advocated. The extreme views entertained by some really eminent authorities, in reference to the employment of antisepsis during and subsequent to labor, border closely upon the absurd, and do not represent the conservative sentiment or the practice of the great mass of successful physicians throughout the country.

Without definite indications for their use, uterine injections should be condemned as dangerous, and even vaginal injections, while free from positive danger, as a routine procedure in private practice, under usual conditions, are unnecessary and had better be omitted. With fairly good sanitary surroundings, the vast majority of women recover without a ripple from the effects of simple labor, and a physiological lochial discharge, like physiological menstruation, may be left to itself, thereby avoiding the risks and the annoyance of uncalled-for manipulation of the genital organs.

The so-called antiseptic pad is not requisite. The discharges may be received with perfect confidence upon clean cloths. The external parts should be bathed or douched with warm or hot water, containing a little carbolic acid, sufficiently often to maintain a state of cleanliness. Sponges should give place to cloths or absorbent cotton.

Any fissures or abrasions about the vaginal outlet may be treated by the application of carbolized oil or iodoform ointment.

In the event that the lochia retains, unduly, its sanguineous character, the state of the uterus, as to the progress of involution, should be ascertained.

THE BLADDER should be emptied six or eight hours after labor, the patient remaining on her back, and using, if practicable, a bed-pan. In some cases—more particularly after difficult and protracted labors, and in nervous subjects—there is inability to pass urine for the first two or three days. The removal of the accustomed pressure from the bladder, the flaccid state of the abdominal parietes, the tumefaction of the urethra and of the meatus on account of prolonged pressure, or from mechanical injury, over-distention, and the enforced recumbent position, explain this difficulty. Change from the horizontal to a sitting or kneeling posture, small doses of ergot, and warm cloths to the hypogastrium and vulva, will generally secure relief. Occasionally the catheter may be required, though it is better not to be officious with instruments in such cases. An ordinary gum-elastic or a soft-rubber catheter is to be preferred to any rigid metal instrument. Care should be taken not to introduce into the bladder, by means of the catheter, any of the secretions or discharges contained within the vagina, for fear of setting up a cystitis.

THE BOWELS are almost invariably inactive after delivery, and in the event that spontaneous evacuation does not occur, the comfort of the patient will ordinarily demand some gentle laxative about the third or fourth day, to be repeated, as required, every two or three days during her confinement to bed. The various saline aperients answer this purpose well. A most acceptable and agreeable substitute for the nauseous dose of castor-oil, which has the sanction of custom and authority, is the solution of citrate of magnesia. A simple enema of tepid water is preferred by some practitioners, and, in many instances, meets every indication. Calomel and other mild cathartics have their advocates, and their appropriate places among useful remedies that may be employed.

THE UTERUS.—Immediately after the expulsion of the placenta, the uterus, if firmly contracted, may be felt like a hard, globular body resting above the pubes. The excessive development of the organ incident to pregnancy and parturition is gradually reduced, by a process of fatty degeneration, and in about two months, unless checked by some untoward circumstance, its normal dimensions are attained. At the end of a fortnight after delivery, it has retracted below the level of the pubic bones; its weight has decreased from thirty or thirty-five ounces to about twelve ounces, and its cavity measures only about four and a half inches.[4] Tonic contraction causes intimate approximation of its tissues, and effectually closes the sinuses and open vessels, shuts out atmospheric air, prevents the formation of clots, and promotes involution. The mucous membrane is soon restored and involution is complete.

THE VAGINA, after the enormous stretching to which it is necessarily subjected during the passage through it of the child, slowly regains its tone and elasticity, though it remains permanently wider than in the virgin state. All abrasions and superficial ruptures heal; tumefaction subsides, and within three or four weeks its normal condition is reached.

THE PERINEUM.—Perineal rupture occurring during labor may unfavorably influence involution. Fissures of the fourchette or slight lacerations of the perineum usually heal if left to themselves, or, at all events, give rise to no subsequent inconvenience. More extensive lacerations should be immediately repaired. Three or four sutures, passed deeply enough to secure close approximation of the ruptured surfaces, may be necessary. The simple interrupted suture, made of catgut or silver wire, or, in the absence of these, of silk, is all that is required.

THE BREASTS.—About the third or fourth day the physiological activity of the breasts begins to attract attention. The secretion of milk becomes active. Prior to that time, a fluid, differing from milk both in composition and appearance, is secreted. This fluid is known as colostrum, and it is believed to possess laxative properties—a provision of nature designed to clear the child's bowels of the meconium.

The mammæ may be turgid, nodular, and painful, and more or less general disturbance may be associated with this local condition. The pain sometimes radiates from the breasts across the chest and down the arms. The axillary glands may also become sensitive and enlarged.

For the sake of the child, great care should be taken to preserve the integrity of this function. If the breasts are pendulous, they should be supported by some appropriate device. The accumulated milk, which contributes to the pressure from within, should, when the child is not

equal to the demand, be gently drawn from the ducts by the lips of the nurse while the breast is supported between her hands, moderate friction or expression being at the same time made on the gland. Some nurses are very skilful in drawing breasts, and depletion by this means is preferable to the use of the breast-pump, which is attended with some risk. Puppies have been called into requisition for the same purpose.

Topical applications of belladonna, for its anodyne effect, are useful. Anointing the breasts with olive-oil is recommended. If the milk should not be required for the child, belladonna, iodide of potassium, and phytolacca decandra may be given internally. If, however, the child is to be nursed, great circumspection should be observed in the use of this class of remedies, on account of the liability of permanently arresting the secretion. Quinine is frequently indicated.

The constitutional excitement which usually attends painfully distended breasts, and which is marked by headache, flushed face, anorexia, coated tongue, thirst, slight increase of temperature, and some quickening of the pulse, was formerly described as milk-fever.

The very existence of such a disease is now denied, and it is characterized as "a vague tradition that does not rest upon classic observation." Certainly, it is now regarded as of rare occurrence.

According to Galabin,[4] a rise of temperature about the third day is often due to some transient septic or traumatic disturbance; but he adds that it may be caused about this time by irritation and tension, or by slight inflammation of the breasts.

Playfair[5] says it has been immensely exaggerated. It is rare in these days, since starving of puerperal patients is no longer considered necessary. There does not seem to be any sufficient reason for referring it, even when tolerably well marked, to septicæmia. The relief which attends the emptying of the breasts seems sufficient to prove its connection with lactation, and the discomfort which is necessarily associated with the swollen and turgid mammæ is, of itself, quite sufficient to explain it.

Barker[1] does not regard the prevailing opinion respecting this question as change in sentiment merely, or as dependent upon information derived from the more general use of the clinical thermometer, but to the fact that there is an actual decline in the occurrence of a veritable disorder in consequence of improved hygienic management—in securing rest, in giving good nourishment, and in the early application of the child to the breast.

The nipple, in primiparæ, should be shaped and developed by drawing it into an ordinary glass nipple-shield, or into the neck of a suitable bottle, which may have the contained air rarefied by filling it with hot water and emptying it immediately before it is applied. As the bottle cools, the nipple is forced into its mouth by atmospheric pressure.

Sensitive, abraded, or fissured nipples sometimes demand attention. Sponging with cold water and thorough drying after every application of the child to the breast may prevent or relieve these troubles. Sometimes astringent applications, or the solid nitrate of silver in the case of obstinate fissures, are required, or the habitual use of a nipple-shield may be necessary. The shield should have a flaring glass base and a rubber mouth-piece. Temporary withdrawal of the child from the breast may become necessary.

Deficient flow of milk, known as agalactia, or excessive secretion, galactorrhœa, may require interference. The former condition may best be treated by attention to the hygiene of the woman, and by improving her nutrition. Milk is especially serviceable for this purpose, and its good effect is enhanced by the addition of a little brandy or whiskey, if the spirit agrees with the patient, and is not otherwise contra-indicated. Porter, ale, malt-extract, or beer is used by some persons with satisfaction. Of course, organic defects in the gland are beyond the reach of these means. In galactorrhœa the milk is apt to be of poor quality, and invigorating measures of treatment are usually indicated. Certain drugs, especially belladonna, iodide of potassium, and phytolacca decandra, are reputed to possess the property of directly decreasing the lacteal secretion. These may be cautiously used, when necessary, in connection with general hygienic management. The amount of liquid ingested should be restricted as much as possible, and hydragogue laxatives may be advantageously employed.

The Binder.—The use of the traditional binder after delivery appears to be more a matter of comfort than of necessity, and as most women prefer it there can certainly be no valid objection to its employment, provided it be properly applied. It is very doubtful if it contributes to the maintenance of uterine contraction, or if it tends to the preservation of a symmetrical figure; but it does afford support to the stretched abdominal walls, and does prevent disagreeable sagging of the abdomen pending the restoration of normal muscular contractility.

Rest for a few hours after labor is very important, and very grateful to the patient. The room should be pleasantly shaded, avoiding a glare of light on the one hand, and darkness on the other. Quiet should be enjoined, and every facility for undisturbed repose afforded. If necessary an opiate may be administered.

The time at which a puerperal woman may leave her bed with safety cannot be fixed by any arbitrary rule. It varies with the individual, and depends, in part, upon her recuperative energy, and the absence of retarding complications, the severity of the labor, and the general condition of the patient, irrespective of puerperal experiences.

Attempts to prescribe a definite period of confinement show the futility of all such efforts. One writer (White) advocates sitting up a few hours after labor. Others (Goodell, Solovieff) fix upon the second day—allowing their patients to sit up while the bed is being made, and so on until the fifth day, when, if so disposed, they may get up and dress themselves. Others[6] (Avrard, Chapman) say the puerperal woman must keep her bed for three or four weeks—often longer, never less.

Here, as elsewhere, sound common-sense ought to prevail. This, joined with experience, teaches that the majority of puerperal women, under favorable circumstances, may leave their beds without detriment from the tenth to the fifteenth day, though they should keep their rooms for three or four weeks, and avoid physical exertion for even a longer period.

The Food of the puerperal woman should be sufficient in quantity, and suitable as to quality. The most extreme and unreasonable views are entertained upon both sides of the question of dietetics. Because some women have been starved, others, forsooth, need not be glutted. The golden mean—the middle course is safe. It should be remembered that the appetite and the digestion are impaired by the fatigue and anxiety of labor, and by subsequent confinement to bed. The stomach should not be overtaxed, but adequate support should be secured. Liquid food, at first, is preferable. Milk, tea, animal broths, and eggs may be gradually supplemented as convalescence progresses. The influence of the mother's diet upon the nursing infant, through the medium of her milk, should not be overlooked.

The lying-in chamber should be well ventilated and comfortably warmed in winter. All soiled clothing, excretions, and discharges from the patient must be promptly removed. No disinfectant or deodorizer can take the place of fresh air, which, without involving exposure, should be freely supplied.

Good nursing is of inestimable advantage to the patient, and a source of great satisfaction and comfort to the physician. A quiet, gentle, intelligent, and not over-officious attendant contributes largely to the successful conduct of a case, and to its auspicious issue.

Pathological Complications.—The normal progress of puerperal convalescence may be interrupted by the intercurrent development of a number of more or less grave complications, some of which merely retard improvement and delay recovery, others, of more serious import, jeopardize the existence or actually terminate the life of the patient, who has survived the manifold perils of pregnancy and parturition.

HÆMORRHAGE.—The hæmorrhages of the puerperal period are primary, or post-partum, and secondary, or puerperal. Post-partum hæmorrhage may occur immediately after the birth of the child and before the placenta is expelled, or it may follow the delivery of the placenta.

It is one of the most serious and alarming accidents to which the puerperal woman is exposed, and unless the medical attendant is at hand, and is prepared to act promptly and courageously, death may ensue in a few minutes. In post-partum hæmorrhage proper, the blood escapes from the open extremities of the uterine vessels, which are torn across by the separation of the placenta. These vessels are compressed, physiologically, by the firm contraction of the uterus, which effectually closes them, and they are further occluded by clots which, in the form of thrombi, seal up the ruptured ends.

The condition of the uterus which makes this form of hæmorrhage possible is imperfect contraction. There can be no hæmorrhage from the uterine vessels with complete, permanent contraction. There is no safety without it.

Any circumstance, whether functional inactivity, organic defect, emotional disturbance, or mechanical obstruction to firm closure of the uterus, acts as a cause and invites the occurrence of hæmorrhage. Likewise, any cause that so impresses the constitution of the blood as to prevent the formation of thrombi, and any condition that interferes with the circulation in such manner as to produce congestion of the uterus or of the peri-uterine structures, or any derangement of the heart's rhythmical action, predisposes to hæmorrhage and may occupy a direct causative relation to it.

If the flow should continue notwithstanding tonic uterine contraction, the probabilities are that it comes from some laceration of the uterus, cervix, vagina, or vulva, and thorough exploration will reveal its source.

The symptoms vary in severity, according to the suddenness and violence of the occurrence. In general there is pallor, faintness, vertigo, impairment or loss of vision, thirst, dyspnœa, gasping, and a weak, thready, sometimes imperceptible pulse. In extreme cases syncope and, possibly, convulsions speedily follow. There is generally a gush of blood from the vagina simultaneously with the occurrence of the first symptoms. The flow continues in a more or less copious stream until arrested. Occasionally there is no external appearance of the hæmorrhage, but the blood flows freely into the cavity of the womb, which becomes rapidly distended by its accumulation, and the same train of general symptoms is observed. This is denominated concealed hæmorrhage.

Fortunately, this terrible experience may be averted, except in very rare instances, by the skilful management of labor. The attention should be directed to securing tonic uterine contraction as a prophylactic, and also as a curative means when the hæmorrhage occurs. External pressure and manipulation with the hand over the fundus, and ergot subcutaneously and by the mouth, may suffice for this purpose. Two grains of ergotine dissolved in water, or one drachm of the fluid extract of ergot, may be used for the hypodermatic injection. If immediate contraction does not follow the pressure upon the fundus, pass the other hand into the vagina, and, if necessary, into the uterus—continuing to grasp the fundus—and extract all clots or retained fragments of secundines; or, if the placenta has not been expelled, it must be removed, after gently separating any adhesions that may be found to exist. In the event this manipulation does not cause contraction, pass into the uterine cavity a piece of ice about the size of a hen's egg, a pared lemon, gashed about the surface to admit the ready expression of the juice, or a clean handkerchief or a sponge saturated with vinegar. Bimanual compression, whereby the uterus is anteflexed, may serve as a valuable temporary expedient. The injection into the womb of hot water is an efficient resource. This may be readily done by passing the nozzle of a rubber-ball syringe into the cavity, special care being taken to expel all the air from the instrument. The returning stream may be received in a bed-pan. The child, meanwhile, should be put to the breast, and an opiate to allay agitation is usually indicated. Some advantage is derived from the ingestion of hot fluids, either milk, tea, or water.

Injecting the cavity, or swabbing the internal surface of the uterus with styptics, remains as a last resort. The practice is not free from danger, but under the pressure of an immediate and urgent demand it is certainly justifiable. The tincture of iodine is to be preferred for this purpose. It is in effect both an active antiseptic and a styptic. The officinal tincture may be diluted with two to four parts of water, or used, if considered desirable, in full strength. The solutions of persulphate, the subsulphate, or the perchloride of iron—one part to five of water—are powerful styptics, and may be used instead of the iodine; but the hard, disagreeable clots which the iron solutions produce constitute a serious objection to their employment.

The womb should be empty when the styptic applications are made. If practicable, it is well to wash it out with hot water, to be immediately followed by swabbing its surface, or by the injection of from one to six or eight ounces of the styptic solution.

After the cessation of the hæmorrhage, stimulants to sustain the circulation and to prevent syncope may be cautiously administered. The head should be kept low. If necessary, the foot of the bed may be raised. Absolute quiet in the recumbent posture should be assiduously maintained. If the loss of blood has been great, compression of the aorta or bandaging the limbs for several hours has been recommended. In extreme cases successful resort has been had to transfusion. Arterial and venous blood, saline solutions, and milk are thus used.

Arterial blood may be conveyed through the medium of a connecting tube and cannula, from the dorsalis pedis artery of the donor to the corresponding artery of the patient. Venous blood may be obtained from the median basilic, or from other superficial veins, and conducted by the same apparatus into a vein of the patient; or venous blood may be drawn, defibrinated, and introduced into the patient's veins by means of a funnel, tube, and cannula. Lamb's blood has been proposed as a substitute for human blood.

A solution of the chloride of sodium—one drachm to a pint of water at a temperature of 100° F., to which thirty grains of bicarbonate of sodium may be added—has been recommended for injection into the veins in lieu of blood. A quart or more of this solution may be thrown very slowly into one of the veins of the arm. It fills the empty vessels, but does not nourish the vital organs. Its reviving effect is apt to be only transitory.

Milk, proposed by Dr. T. G. Thomas, to be used in the same manner, has been employed with fair success. Good results have been reported from the hypodermatic injection of the warm saline solution, as has been proposed in the collapse from cholera.

The practical value of transfusion as a remedy in puerperal hæmorrhages is variously estimated. There are many impediments to its successful employment, especially in private practice.

Landis[7] tersely sums up his conclusions in reference to the utility of the measure, by declaring: "If the patient is able to endure the operation, she does not need it; if she does need it, she is too weak to bear it."

The introduction of the saline solution or of the milk is not attended with such difficulties as are inseparable from the transfusion of blood.

Puerperal or *Secondary Post-partum Hæmorrhage* may occur at any time from six hours to three or four weeks after delivery. The causes are substantially the same as in primary hæmorrhage. This event need not be feared in a healthy subject, with a uterus completely emptied, free from disease, and which is firmly and continuously contracted.

The recognized causes of puerperal hæmorrhage are: Albuminuria, purpura, puerperal poison, malaria, emotional excitement, secondary inertia, uterine fibroids and polypi, adhesions, retained coagula and placental fragments, inflammatory ulceration and severe laceration or malignant disease of the cervix, partial or complete in-

version of the uterus, pelvic cellulitis, metritis, perimetritis, uterine displacements, subinvolution, distended bladder and rectum, premature sexual intercourse, functional hepatic derangement, cervical thrombus, coughing, vomiting, and physical effort.[8]

These causes may all be grouped in three classes: 1, Impoverished blood; 2, mechanical impediment to uterine contraction; 3, disturbances of the circulation, either general or local.

In the management of "secondary puerperal metrorrhagia" the essential prophylactic means consist in the correct conduct of labor and a proper puerperal hygiene. If the flow should be profuse, energetic measures are required, but if the discharge should be only slight yet continuous, less active treatment will suffice.

The removal of the offending cause, when practicable, is the prime requisite. This consists in the withdrawal from the uterine cavity of any substance that may prevent physiological closure of the womb; the correction of any constitutional vice that may be present, and of any functional impediment to the integrity of the circulation.

The cervix may have retracted, so that dilatation by means of sponge-tents may be necessary to make intra-uterine exploration and the removal of any foreign material possible.

The hand laid upon the abdomen will reveal the state of the uterus as to contraction or relaxation. When compression is indicated, it should be made by grasping the fundus, aided, if necessary, by passing two fingers of the other hand into the vagina and exerting bimanual pressure. The vaginal tampon is not trustworthy, especially soon after delivery. It may prevent the external flow, but possibly, only by converting it into concealed hæmorrhage. Barker[1] recommends the cervical tampon, unless the os is patulous, allowing it to remain six or eight hours, and guarding against distention of the uterus by a compress over the hypogastrium, secured by a firmly applied binder. He has used the sponge-tent as a cervical tampon successfully on the third day. In any event, he confidently endorses the value of an injection into the rectum of one ounce of the oil of turpentine and half an ounce of olive-oil, to be retained as long as possible.

The injection into the uterus of hot water or the application of the styptic solutions, as recommended in primary hæmorrhage, may be demanded. Care must be taken, however, to secure a prompt return of the injected fluid and to avoid the introduction of air.

Ergot, quinine, and opium, with, perhaps, digitalis and strychnine, and stimulants, have their appropriate places in the management of these cases. In threatened collapse the hypodermatic injection of whiskey or ether may be necessary, on account of the importance of securing the stimulant effect promptly, and in consequence, possibly, of vomiting, and of the functional inactivity of the stomach. The advantages of position, of undisturbed repose, of a thoroughly digestible but sustaining diet, should be secured to the patient.

Faradic electricity has been successfully used to induce uterine contraction, and it would be entirely appropriate in either form of post-partum hæmorrhage, but the battery necessary for its production is seldom at hand in the emergency. If it is employed, one electrode should be applied over the fundus, and the hand, probably already in the vagina or in the uterus, may be utilized as the other pole by placing the second electrode in contact with the arm or forearm of the operator.

Puerperal Fever.—The most formidable complication of the lying-in period is the disease known as puerperal fever—a term which has been a familiar landmark in medical nomenclature for more than a century and a half, and with which it would be difficult to dispense in the absence of an acceptable and comprehensive substitute.

The nature of this affection has served as the basis of many vehement controversies, and it still challenges the most earnest discussions between the advocates of the different doctrines which are maintained respecting its character.

It has been ascribed to retention of the lochia, to metastasis of the milk, to failure on the part of the excretory organs to eliminate effete material, to metritis, to erysipelas, etc. But these and other theories, proposed from time to time, have, one after another, been abandoned, and now two prominent doctrines are upheld. These are:

First, the doctrine of a fever peculiar to puerperal women, the symptoms of which are essential and are not the consequence of any local lesions; a zymotic disease resulting from some unknown blood-changes, of the specific cause of which changes we are ignorant, but the determining cause of which may be epidemic influence, contagion, infection, or probably nosocomial malaria.[1]

Second, the doctrine that puerperal fever is puerperal septicæmia, analogous to, if not identical with, the so-called surgical fever, modified by the physiological state of the subject, and usually associated with various local inflammatory lesions.

While the theory of septicæmia is not free from difficulties, it is unmistakably evident that the tendency of modern thought, in the light of more recent researches, is strongly toward the acceptance of this doctrine, and that puerperal fever is now generally regarded as an infectious and contagious disease, produced, for the most part, by the absorption of septic matter through wounds in the genital tract, caused by the separation of the decidua and by violence inflicted during the act of parturition, and usually complicating, or complicated by, inflammatory lesions within the pelvis or the abdomen, which constitute, in their different forms, the several varieties of this affection.

The acute inflammatory lesions referred to as usually coexistent with the blood-poisoning, manifest themselves primarily as vaginitis, endometritis, metritis, pelvic cellulitis, pelvic peritonitis, general peritonitis, phlebitis, and lymphangitis, and secondarily, in the serous membranes, as pleuritis, pericarditis, and meningitis and also in purulent inflammation of the joints. Pyæmia and circumscribed inflammation of the subcutaneous areolar tissue, terminating by resolution or by suppuration, are among the secondary affections.

Inflammation of the genital mucous membrane may be superficial—catarrhal merely, or granular—and it may spread from the endometrium along the Fallopian tubes, producing salpingitis; and by extending still farther, may involve the peritoneum and set up a more or less diffused peritonitis; or the inflammatory action may go deeper, resulting in ulceration. These ulcers may assume a diphtheritic form, especially around the vaginal outlet, and round bacteria or micrococci are plentifully found in them. With vaginitis are associated painful micturition and defecation.

In metritis, or inflammation of the uterine parenchyma, the tissues become soft and relaxed, and involution is retarded or arrested. The muscular wall is œdematous, or the connective tissue may be filled with a sero-purulent fluid, or small collections of pus may occur. The margins of any fissures about the cervix may become sloughy or gangrenous. The uterine veins and lymphatics most likely share in the morbid process in operation around them. The inflamed veins are thickened, and contain lymph and, rarely, pus. The lymphatics are frequently loaded with pus, and upon cross-section present to the eye the appearance of intramuscular abscesses.

The cellular tissue in immediate proximity to the uterus may be invaded, giving rise to what is known as parametritis, or the inflammatory action may extend to more remote layers of connective tissue within the pelvis, thus establishing pelvic cellulitis. More or less swelling occurs, caused by the effusion of serum and, later, by the exudation of lymph. Suppuration may result, with, possibly, burrowing of pus and the formation of fistulous openings, or the inflammatory products may be absorbed, leaving usually some induration. In the more severe septic forms of cellulitis the exudation degenerates into a turbid, purulent fluid which fills the interspaces of the tissues.

Peritonitis may be limited to that portion of the peritoneum within the pelvis—pelvic peritonitis or perimetritis—or the inflammation may invade the abdominal cavity, resulting in general or diffused peritonitis, which is usually a prominent, and almost a constant, feature of puerperal fever. Tympanitic distention of the intestines is a conspicuous and early symptom. In mild cases the exuded lymph either floats in the form of flakes in the effused serum or it is spread over the surface of the abdominal viscera. The peritoneum is lustreless, roughened, and ecchymosed, and in the severer types contains more or less pus.

The inflammatory affections above described may occur as independent lesions, associated with puerperal processes, but without clinical evidence of septic infection; and, on the other hand, septicæmia may run its course in rapidly fatal cases and no appreciable disease of the genital organs or of the peritoneum be detected by ordinary methods of investigation. Nevertheless, as remarked by Playfair,[5] there is little doubt but that in these intense cases profound pathological changes exist in the form of alteration of the blood and degeneration of tissue.

If the disease should be protracted, pyæmia is apt to be developed, the prominent symptoms of which are frequently recurring rigors, high temperature, profuse sweating, and localized inflammations and abscesses. Pyæmic abscesses in the lungs and in the kidneys frequently result from emboli, formed by the disintegration of an infected venous thrombus.

The appreciable symptoms of puerperal fever are usually manifest on the third day after labor. Exceptionally, they may be observed on the second, or be delayed as late as the seventh day. The attack may be very acute in its symptoms and course, or it may be less intense—a form sometimes described as subacute. The onset is frequently insidious. It may be indicated by a sharp chill, a slight rigor, or only by chilly sensations. The pulse runs up to 100, 120, or 150, or even higher. The temperature mounts to 102°, 104°, or 106°. The lochia generally becomes offensive and is diminished in quantity, or is suspended. The secretion of the milk may be prevented or, if it has commenced, is often, though not always, arrested; abdominal pain and tenderness are usually present, though they may be slight and are occasionally wanting. Constipation may at first be present, and be succeeded by diarrhœa. The bowels are distended with flatus. Tympanites sometimes constitutes the most severe symptom. Nausea and vomiting are apt to occur. The vomiting and diarrhœa may seriously hamper efforts to nourish the patient, and thus contribute directly and indirectly toward prostration. Some cases are notably marked by depression, presenting throughout an asthenic type, sometimes called typhoid. In this form low delirium is apt to be developed at night, and pulmonary complications are more likely to occur.

Fatal cases of the intense variety usually run their course in a week. Local complications modify attacks by interjecting their own peculiar symptoms among the general or constitutional symptoms. In some cases one train of symptoms predominates, in other cases another set of symptoms is more prominent. In grave cases an anxious expression of countenance is observed, but it is usually unaccompanied by fear of impending danger.

In the less intense or the subacute form of the disease the symptoms are not so active. It develops later, usually lasts longer, and may be very mild in its manifestations. Some cases are characterized by a succession of chills at irregular periods, which may, in spite of all treatment, continue to recur over and over for several weeks. These symptoms are probably indicative of mild pyæmia.

The different pelvic inflammations which belong to the clinical history of puerperal fever are not always to be discriminated. Several frequently coexist, so as to render isolation and differentiation of the individual lesions impossible.

The cause or causes of puerperal fever, whatever they may be, are generally admitted to be influenced by the physiological condition of the puerperal woman. The state of the blood, of the nervous system, and of the genital organs form important elements in estimating correctly the effects of pathogenic agencies. Most authorities agree upon the possibility of self-infection, and all concur in the certainty of infection from without.

"Puerperal fever is puerperal septicæmia," is the concisely expressed creed of Thomas,[9] who adds that the essence of the disorder is a poison absorbed into the blood of the parturient woman through some solution of continuity. Whatever may be the character of this poison, we know that there are two, and only two, methods by which it can reach the parturient tract and exert its baneful influence. First, it may be carried into the vagina by the atmosphere, in which it floats as an impalpable substance; and second, it may be carried to any part of the genital tract by the fingers of the doctor or nurse, by sponges, cloths, towels, and instruments, and by the clothing of the patient.

After reviewing the pathology of puerperal fever, Galabin[4] concludes that the affections which have been included under the title of puerperal fever, though they have a common element in the reception of some poison, cannot be reduced to a uniform pathology, but are various in their nature and origin. According to the new nomenclature of the Royal College of Physicians of London, the title puerperal fever is to be discarded, and the diseases are to be classed, according to their most prominent character, as puerperal peritonitis, puerperal cellulitis, puerperal septicæmia, puerperal pyæmia, and the like. Galabin makes the following classification: 1. Endogenetic toxæmia, in which noxious material is produced in the blood itself, or retained in it through deficient action of the organs of excretion. 2. Septic intoxication, in which a chemical poison only is absorbed. 3. Septic infection, in which organisms multiply in the blood or in the tissues, or in both.

Septic intoxication and septic infection cannot generally be practically distinguished.

Lusk,[2] who regards puerperal fever as an infectious disease due, as a rule, to septic inoculation of fresh wounds in the genital tract, says it seems impossible to make all of the facts coincide with the theory that the genitalia of the puerperal woman are the exclusive point of entry of infectious materials into the system. The deleterious materials may find other channels of entering the system than wounded surfaces; and while he cannot go as far as Tarnier, who believes that it is by the lungs that poisoning often, if not always, occurs, it does not seem time to give up the idea that the respiratory and digestive tracts may allow the passage of material of a specific character. He attributes to the lochial discharge much of the unhealthfulness of maternity wards.

"The maligned lochia" is an expression used by Barker,[10] who, in the form of a query, intimates that nature has wisely arranged to furnish the best fluid for constantly bathing the bruised and lacerated tissues of the parturient canal.

A number of different poisons or causes, but no specific puerperal poison, and no specific puerperal fever, represents the views of Leishman.[11]

Parvin[6] utterly repudiates the doctrine of the autogenesis of puerperal fever. He considers it a confession of ignorance, and the very pessimism of obstetric medicine. But while decomposing organic matter in the vagina or uterus does not create the disease, it furnishes a nidus for the lodgement and propagation of septic germs.

Playfair[5] holds that the assumption of a puerperal miasm is not necessary, and that the most practical division of the subject is into cases in which the septic matter originates within the patient, so that she infects herself, the disease being then properly autogenetic; and into those in which the septic matter is conveyed from without, and brought into contact with absorptive surfaces in the generative tract, the disease then being heterogenetic.

Barnes[3] declares that puerperal fever is fever in a puerpera, and that we must abandon the vain attempt to

find one definite puerperal fever, and recognize the clinical truth that there are puerperal fevers—autogenetic fevers, resulting from the retention of excretory, and the absorption of septic, matter; and heterogenetic fevers, due to the reception of extraneous poisons of cadaveric, puerperal, or obscure animal origin, or that can be traced to certain zymotic influences.

The influence of bacteria in the production of puerperal fever has not been definitely established. Authorities differ widely in their estimate of the importance of microbes as an essential agency—some affirming, others denying, their potency. There is unquestionable evidence, however, to sustain the fact of their presence in the form of round bodies, or micrococci, which have been found abundantly, either singly or united in chains or clusters, in the tissues and in some of the fluids of the subjects of puerperal and of surgical septicæmia and pyæmia. Micrococci are also found in other diseases, but it does not follow, because of similar microscopical appearance, that they all possess pathogenic identity.

The view is generally accepted that diseases clinically inseparable from puerperal fever may originate by exposure to the poisons or to the products of certain zymotic diseases—notably scarlet fever, diphtheria, erysipelas, typhus, and typhoid fever—and also by contact, direct or indirect, with suppurating wounds, decomposing animal matter, and, possibly, to the influence of sewer-gas and of other impure air; though it appears to be certain that exposure to these poisons does not invariably produce this disease, and, moreover, according to the observation of Playfair,[5] any zymotic disease may attack a newly delivered woman and run its characteristic course without any peculiar intensity.

While puerperal fever is believed to be both contagious and infectious, in the sense that it may be communicated by a virus or by a miasm—by a palpable or by an impalpable product—it is more than probable that different forms vary in respect to their communicability, and that some forms of the disease are much more readily communicated to susceptible subjects than are others.

The treatment of puerperal fever is prophylactic, local, and constitutional. The preventive treatment has reference to the judicious management of labor, to the strict observance of a conservative and sound puerperal hygiene, and to the conduct of the medical attendant and the nurse in relation to the conveyance of any poison to the patient. Scrupulous cleanliness of the hands, instruments, clothing, bedding, and of everything surrounding or that may come into contact with the puerperal woman, is of paramount importance. With absolute cleanliness, the usefulness of antisepsis shrinks into comparatively narrow limits. Nevertheless, it is a simple matter to use the bichloride-of-mercury or the carbolic-acid solutions in washing the hands and in cleansing the instruments, and it is certain, with ordinary care, that no harm will be done, unless, perchance, the antiseptic should be relied upon as a substitute for, and to the exclusion of, that uncompromising cleanliness which is herein earnestly advocated, and which must precede or accompany antisepsis if we would not invite disappointment.

The duty of the physician in respect to contagious diseases—to those diseases that are supposed to hold some relation to the causation of puerperal fever—and to septic material of all kinds, is plain. The danger of infecting his patient should deter him from attending her directly after contact with such poisons, or when closely confined with them. Of course, a physician engaged in general practice cannot refuse attendance upon obstetric cases every time he encounters infectious diseases or septic matter; yet the risks, under these circumstances, demand the observance of extraordinary precautions as to his person and his clothing.

Are antiseptic vaginal and uterine injections to be reckoned among legitimate preventive measures? If it should appear that they are in themselves harmless, then an affirmative answer may be given. If, on the other hand, their use involves a risk, even a slight risk, to the patient, the propriety of the procedure may be very seriously questioned.

Barker[10] says: "Antiseptic injections, both vaginal and intra-uterine, are of great service when the indications for their use are clearly shown by local signs or general symptoms; but they cannot be recommended with safety as a routine practice on theoretical grounds, as, for obvious reasons, they may be most detrimental in retarding the cicatrization of lesions and the other processes of normal convalescence, and are otherwise sometimes dangerous."

Thomas[10] admits that "the arguments which have been brought up against this practice (antiseptic vaginal injections every eight hours after labor), since I read my paper, have had great weight with me. I confess that I feel less firm upon this point than I did, and that in future I shall examine the question carefully before I determine to adhere to my plan." In regard to uterine injections, he deprecated the impression which seemed to prevail that he resorted to them with very little provocation, and adds: "No one could have striven more than I have done to keep within proper bounds the indiscriminate use of this dangerous but valuable resource."

Lusk[10] advocates antiseptic vaginal injections after normal labor in all cases, and uterine injections after difficult labor, where the hands or instruments have been introduced into the uterus, but says:[2] "I know that of late years there has been a strong reaction against the use of vaginal injections in normal childbed, but personally I have experienced none of the disagreeable effects ascribed to them. Indeed, both my hospital and private patients speak of them as soothing and grateful. I therefore have had no ground to discontinue them. That they are indispensable, I do not claim. They are no longer used in Vienna, in Prague, nor in the New York Maternity, and yet, none the less, their results have been in the highest degree satisfactory."

"At these institutions, however, vaginal disinfection is vigorously resorted to during and immediately subsequent to labor, and during childbed some form of antiseptic pad over the vulva is employed."

He adds: "Intra-uterine injections should be resorted to with great circumspection. They are not indicated by a simple rise of temperature, and, unless the infection proceeds from the uterine cavity—which is the exception—they are unnecessary."

Braun von Fernwald, in discussing prophylactic uterine injections, is quoted as saying: "We must protest against injections made by physicians into the uterine cavity; such meddlesomeness is more likely to do harm than good." Our author adds: "This corresponds to my own experience."

Galabin[4] advises antiseptic vaginal injections twice daily in all cases, but says of uterine irrigation: "Its indiscriminate use after all cases of labor has been found to be rather injurious than beneficial, and to increase rather than diminish the number of cases of septicæmia."

Parvin[6] thinks that, in the absence of any indication, vaginal injections are not necessary.

Playfair[5] advises antiseptic vaginal injections when the lochia is fetid, and thinks uterine injections should not be omitted in cases in which self-infection is possible; "and, indeed, when there is no reason to suspect a local focus of infection, the use of antiseptic lotions (intra-uterine injections) is advisable as a matter of precaution, since it can do no harm and is generally comforting to the patient."

Leishman[11] recommends antiseptic vaginal injections "if the fetor of the lochia is unusually great, or if the parts have been lacerated."

Barnes[3] says: "Wash out the uterus twice daily from the second day; should there be the slightest rise of temperature and pulse, the intra-uterine injection is imperative."

Measured by the rule above proposed, in the light of the evidence adduced, notwithstanding high authority to the contrary, the conclusion is inevitably reached, that under normal conditions, with fair sanitary surroundings, neither vaginal nor uterine injections are to be rec-

ommended as a routine practice, upon the theory of forestalling possible morbid developments, which may, if they should occur, produce a state of general septic toxæmia. But so soon as a probable diagnosis of commencing puerperal fever is made, based upon the presence of the usual initial symptoms—a sustained elevated temperature, associated with a quickened pulse, preceded, possibly, by a chill, and accompanied by pelvic pain or tenderness in the hypogastric region, tympanites, headache, flushed face, and general restlessness, with, perhaps, an offensive lochial discharge and arrested uterine involution, occurring about the third or fourth day—a warm vaginal injection of carbolic acid ʒ ij. to water Oj., or corrosive chloride of mercury one part to water 2,000 or 3,000 parts, or of tincture of iodine ʒ j. to water Oj., should be given and repeated two or three times daily. Meanwhile, agitation and pain should be subdued by an opiate. Morphine, hypodermatically, is usually the most available mode of administration. If the symptoms continue without abatement or with increased activity, the injection into the uterus of one of these antiseptic solutions should be practised, always by the medical attendant himself. The several dangers pertaining to this procedure—namely, shock, uterine hæmorrhage, injecting air or forcing the liquid into the peritoneal cavity—may generally be avoided by observing the utmost gentleness in all the manipulations, by carefully expelling all air from the injecting apparatus, and by warming the solution to from 100° to 105° F.

Great care should be taken to secure the ready egress of the injected fluid from the uterine cavity. If the os is patulous, as it usually is under these circumstances, this may be readily accomplished. For injecting the solution, either an irrigator or fountain syringe, or a hand-ball syringe, may be used.

The nozzle may be passed directly through the internal os, or it may be attached, through the medium of rubber tubing, to an ordinary gum-elastic catheter—or to some of the special tubes or catheters devised for this purpose—which should be carefully carried, while the liquid is gently flowing through it, into the womb. The return current may be received in a bed-pan, or conveyed by means of a rubber cloth, depending over the side of the bed, to a vessel on the floor. A thorough vaginal injection should first be given, to obviate the risk of carrying any septic matter from the vagina into the uterus. If frequent or very copious injections should become necessary, the danger of carbolic-acid or mercurial poisoning may be escaped by using simply warm water at first, to be followed, without withdrawing the tube, by a few ounces of the medicated liquid. The advisability of repeating this procedure once, twice, or thrice daily must depend upon the results obtained in the first trial. If improvement follows, it should be tentatively continued. If, on the contrary, unpleasant consequences ensue, it may be proper to abandon it at once.

Any fragment of the placenta or of the membranes, and any clot, that may remain in the uterus or the vagina should be carefully removed.

As an antipyretic and, possibly, as an antiferment, quinine is of great value in these cases. It should be given in full doses repeated twice daily, or, in some cases, it may be prescribed in smaller doses at shorter intervals. Salicylate of sodium and antipyrin may be employed as substitutes, if the quinine should fail or not be well borne. In some forms of the disease the remarkable tolerance of opium necessitates its free use to ease pain, quiet irritability, and secure sleep. Chloral, as a hypnotic, may sometimes be advantageously added. Alcohol is of pre-eminent service. It is usually tolerated in large doses. It reduces the temperature, prevents waste, and wards off asthenia. As a cardiac sedative, veratrum viride occupies the first rank. It may usually be given, noting the effect, in doses of five drops every three or four hours. It is not incompatible with opium or alcohol. It, too, is a conservator of the vital forces, besides contributing directly to the comfort of the patient. But let it be distinctly understood that neither veratrum nor other cardiac sedative is indicated if the rapid pulse is the result of a feeble heart. Frequent sponging of the body with cold or tepid water, or with alcohol, is beneficial. The cold bath and the cold pack are recommended for reducing bodily heat. They are difficult to administer in private practice, and are not entirely free from danger. Topical cold to the abdomen, as ice or cold-water coils, sometimes accomplish good if maintained for a number of hours; but in some cases the warm applications—poultices, turpentine stupes, etc.—are more comfortable and appear to act better. Ice to the head is sometimes employed.

To allay nausea, ice, iced champagne, and sinapisms to the epigastrium, are among the most trustworthy resources. Constipation, if it exists, may be overcome by enemata or laxatives cautiously given. Puncture of the intestines with a very fine, hollow needle, in distressing tympanites, has been successfully practised.

The diet should be nutritious and digestible; only liquids, as milk, animal broths, and gruel, should be allowed.

Any intercurrent local complication that may develop must be treated on general principles.

In estimating the value of any mode of treatment, it should be remembered that a large proportion of the febrile attacks of puerperal women pursue a favorable course and may be expected to terminate after several days, and even under the most discouraging assemblage of symptoms, hope of recovery should not be abandoned.

Phlegmasia dolens, or phlegmasia alba dolens, when it attacks the puerperal woman, appears, as a rule, during the second or third week after labor. The prominent local characteristics, when fully developed, are pain, swelling, a brawny hardness, and a glistening white appearance of the affected parts. It occurs commonly in one or both of the lower limbs, as a rule in one only, and exhibits a decided predilection for the left side. When both legs are invaded, the manifestations are not simultaneous, but the second is attacked from a day to a week later than the first. The disease sometimes occurs in the arms, and it has been observed in men. When the arms alone are involved, it is not often of puerperal origin. The shining whiteness of the skin gave rise to the popular appellation of "milk-leg," and suggested, no doubt, the early theory of milk metastasis.

The initial symptom of an attack may be a chill, followed by some reaction, with a sensation of heaviness of the limb, and a dull pain increased by motion. This may be preceded for a day or two by a feeling of great lassitude and depression. As the disease progresses the tenderness becomes extreme, and the degree of swelling may be enormous, the limb sometimes being double its natural size.

The swelling may commence in the thigh and extend downward, or it may first appear at the ankle and spread upward. The veins, like hard, knotted cords, may sometimes be felt in the beginning and during the subsidence of an attack. Other veins besides those of the extremities may also be the seat of the affection. The lochial discharge is frequently uninfluenced. The secretion of milk is generally diminished or arrested. In the ordinary course, after a week or ten days amendment takes place; the swelling gradually subsides, and the limb then pits on pressure; the exudation is absorbed, the circulation is restored, and muscular movements become possible. The usual duration of an attack is five or six weeks.

Under less favorable conditions, suppurative phlebitis may ensue, abscesses may develop, and extensive suppuration of the subcutaneous and intermuscular cellular tissue sometimes occurs. Occasionally the affected vein is permanently obliterated. A thrombus may undergo purulent softening and disintegration, and thus produce infected emboli, which may, in turn, originate metastatic abscesses at the points of lodgement in various parts of the body; or a large fragment of a thrombus, in consequence, possibly, of imprudent manipulation or premature use of the limb, may be carried by the circulation through the right side of the heart and produce sudden death by plugging the pulmonary artery.

The pathology of phlegmasia dolens has given rise to much controversy, which has served to develop numerous specious theories, none of which satisfactorily explains all of the morbid phenomena that are observed.

The doctrines of phlebitis, of venous thrombosis, and of inflammation or obstruction of the lymphatics, are all maintained. Some authorities now hold to phlebitis as the essential lesion, some to peripheral thrombosis, others to the obstruction of the lymphatic ducts and venous thrombosis combined—regarding phlebitis, when it is present, as secondary to the thrombus or to inflammation of the surrounding cellular tissue. The inflammation may be limited to the subcutaneous or to the intermuscular cellular tissue, or it may follow the perivascular connective tissue ; and secondary thrombosis and obstruction of the veins and lymphatics may result from the inflammatory thickening of their walls. A predisposition to this affection is established in puerperal subjects by the hyperinotic state of the blood, by the slow pulse, and by the occurrence of copious hæmorrhage. Varicose veins are also regarded as a predisposing cause.

The veins commonly involved are the iliac, femoral, crural, tibial, and peroneal. Venous thrombus may develop at any point in the course of a vein, or it may invade the veins by extension from the uterus.

A succession of chills occurring in the course of an attack of phlegmasia dolens, accompanied by high temperature, denotes some complication.

Absolute rest, with the leg slightly elevated, and with opium to relieve pain, are the principal indications for treatment. If constipation exists, laxatives or cathartics should be prescribed. Quinine in moderate or large doses is useful. Painting with tincture of iodine along the course of the affected vessels, if they can be traced, or over the entire surface of the limb, has been practised. Stimulating or anodyne liniments, applied with gentle friction after the most acute stage has passed, may be used in lieu of the iodine. The limb should be protected from the pressure of the bedclothing by a frame or cradle, and may be enveloped in cotton-batting or flannel, and covered by oil-silk.

As the swelling subsides some advantage is obtained from a well-applied roller-bandage, and the tincture of the chloride of iron may be administered. Blisters are not admissible, and leeches are not indicated, unless they be used with the hope of averting suppuration in some localized inflammation. If pus forms, it should be promptly evacuated.

In the employment of friction the possibility of dislodging a clot, or of separating a fragment from a disintegrating or softened thrombus, should be borne in mind. Absolute rest should be punctiliously maintained until every vestige of the swelling and of the tenderness has disappeared. The limb sometimes manifests a tendency to swell, after standing or walking, for several months, and is apt to be more or less impaired functionally for a considerable time. Great comfort and advantage may be derived from a close-fitting, long elastic stocking when the patient begins to walk about.

Venous and Arterial Thrombosis and Embolism, and Other Causes of Sudden Death.—The conditions which favor the occurrence of peripheral venous thrombosis invite similar formations in any part of the body, without association, necessarily, with the anatomical characteristics of phlegmasia dolens.

These clots may develop in the right ventricle and, extending into the pulmonary artery, cause death from asphyxia by arrest of the pulmonary circulation. Rarely, thrombi form in the arteries of the puerperal woman as they do in the veins, but circumstances are not so favorable to their development here.

A thrombus may undergo separation or disintegration, and the fragments thus formed, when caught up by the circulation and lodged in vessels of smaller calibre, constitute emboli, which, in turn, may become nuclei for fibrinous accretions and the consecutive development of other thrombi at the points of lodgement.

The pulmonary artery is not alone subject to this accident, but concretions from the left side of the heart may find their way into the systemic arteries, and especially the femoral, brachial, cerebral, and ophthalmic arteries may be thus occluded.

The symptoms depend, of course, upon the character, size, and location of the occluded vessel, and upon the suddenness with which the arrest of the circulation in it may be accomplished.

Sudden death sometimes overtakes the puerperal woman when all seems well. No intimation of the impending disaster is given, but after a brief struggle for breath, life becomes extinct.

This distressing result may be due, as has been shown, to pulmonary thrombosis or to pulmonary or cerebral embolism ; to cerebral hæmorrhage, or to hæmorrhage from the rupture of an aneurism or of an abdominal vessel ; to the entrance of air into the circulation, and to extreme syncope and shock.

Eclampsia.—Convulsions may occur during pregnancy, during labor, and immediately subsequent to, or within several hours after, delivery. It is the last class only that is to be included among the pathological complications of the puerperal state.

If the estimate of one case of convulsions to five hundred cases of labor is correct, and if the statistical results of Lohlein's investigations (quoted by Lusk[2]) are accepted, namely, that eighty-eight per cent. of puerperal convulsions occur in parturient patients, a post-partum convulsion must be an exceedingly rare event. It is fortunately true that such convulsions are very infrequent. From this reckoning, hysterical and epileptic convulsions, and the convulsions symptomatic of cerebral and meningeal lesions, are eliminated.

The convulsions of this period usually develop suddenly, though the foreshadowing symptoms may have been present and passed unobserved during pregnancy or parturition. The most constant premonitory symptoms and signs are headache, vertigo, low spirits, flashes of light, tinnitus aurium, nausea, vomiting, œdema of the face, albuminuria, and tube-casts.

The first convulsive movements may consist of slight twitching of the corners of the mouth or of the eyelids. Other voluntary muscles, especially those of the neck, trunk, and upper extremities, speedily become involved. The muscles of respiration are also apt to be affected. Consciousness is lost, and the respiration becomes irregular and stertorous. After lasting a few moments the muscular spasm relaxes, but the consequent sopor is usually protracted for from twenty or thirty minutes to several hours. A succession of convulsive seizures may occur, and alarming uterine hæmorrhages are sometimes among the unfortunate results.

The precise pathological nature of eclampsia has not been determined. Though defective renal elimination seems to be an important, if not the essential, factor. Changes in the circulation, nervous exhaustion incident to labor, morbid sensibility, and moral disturbances may act as exciting causes.

The prognosis is hopeful in proportion to the short duration, mildness, and infrequency of the seizures, and to the absence of grave fundamental lesions.

The treatment should be addressed to the prevention of the attack if any warning symptoms are present. The vicarious elimination of excretory products by the bowels and by the skin, and the use of calmative remedies, meet these indications. Venesection, so prompt and effective as a remedy in ante-partum convulsions, may sometimes be valuable in this form, but it should be resorted to with discretion.

Chloroform by inhalation is an indispensable and most efficient remedy. After the attack has subsided, the chloroform should be watchfully continued at intervals, and promptly renewed upon the least intimation of recurrence of a paroxysm. The hypodermatic use of morphine, the bromide of sodium or potassium, and chloral either by the mouth or by the rectum, are serviceable adjuncts. When an attack supervenes, the tongue should be guarded from injury by thrusting a cork or a roll of cloth between the teeth. The patient should also be prevented from otherwise injuring herself.

Puerperal Mania is usually developed, when it occurs, within the first two weeks after delivery.

In some cases the attack is foreshadowed by prodromic symptoms, lasting from a few hours only to several days, or its advent may be sudden and startling.

The manner is strikingly changed, and is marked either by excitement or by depression. The patient is sleepless, watchful, suspicious, talkative but incoherent, or maintains a moody silence. Irregular muscular movements and motiveless actions are generally noticed. The symptoms become more intense as full development is reached. The patient may be violent in speech and act. Profanity and vulgarity frequently characterize her expressions. Repeated attempts to leave the bed, to remove the clothing, and to inflict personal injury may be made. The emotional manifestations are sometimes of a pleasurable character, but at other times are profoundly depressed, and even suicide or infanticide may be attempted.

Attacks of puerperal mania are generally associated with a debilitated condition of the system, with defective nutrition, an impoverished condition of the blood, and some derangement of the cerebral circulation, resulting in a state either of anæmia or of congestion. When cerebral congestion is observed, it may possibly be a transient condition of an anæmic brain. Mania may be developed in connection with any of the severe puerperal lesions.

Heredity is an important element in the causation. Social condition and emotional perturbation are influential in its production.

The prognosis is generally favorable. It becomes less hopeful if the attack should be protracted beyond several weeks, and should drift into a state of settled melancholy. A fatal termination is generally due to some intercurrent affection, as metritis, peritonitis, or pneumonia.

Severe treatment is not admissible. Bloodletting and blisters are injurious. The indications point to quieting and supporting measures, and include the removal of any direct or reflex exciting cause. The hypodermatic use of morphine and of hyoscyamine is sometimes effective. Chloral and the bromides of potassium, sodium, and lithium are particularly trustworthy and valuable. These may be administered by the mouth or by the rectum. Severe catharsis is not required, but laxatives or gentle cathartics may sometimes be demanded for the purpose of overcoming constipation. Cold to the head may be tried when called for by undue heat.

An abundant, digestible, and nutritious diet is indispensable. Good nursing is a prime requisite. Tact and clear judgment in the nurse, combined with firmness and gentleness of manner, contribute largely toward the successful management of these cases.

Cardiac sedatives may be necessary on account of the development of inflammatory complications, which should be watched for and appropriately treated when they occur.

Mastitis or Mammitis, and Mammary Abscess.—Inflammation of the breasts, one or both, may be developed irrespective of lactation, but it is much more frequent during the functional activity of the gland, and the majority of cases occur between the first and fifth week after labor.

Inflammation may invade the subcutaneous cellular tissue, the glandular tissue, or the subglandular cellular tissue. In any of these situations it may terminate by resolution, or suppuration may ensue, giving rise, respectively, to subcutaneous or superficial abscess, to glandular or parenchymatous abscess, and to subglandular or deep mammary abscess. Any one of these forms of inflammation or suppuration may exist alone, or any two or all may exist simultaneously or consecutively.

The superficial variety resembles ordinary phlegmonous inflammation occurring in similar tissue elsewhere. It is marked by pain, heat, redness, and swelling, and is apt to end in suppuration, either as small boils around the nipple or as circumscribed abscesses upon any portion of the surface of the breast.

The deeper varieties are accompanied by considerable constitutional disturbance. Fever, headache, thirst, anorexia, and sometimes a rigor, characterize the commencement of an attack. In the glandular form the breasts are excessively tender, swollen, congested, distended, and painful. Lobular induration gives to the organ a lumpy or knotty feel. Several lobules are generally involved, and when suppuration occurs the abscesses are likely to be multiple—developing in some cases one after another, and extending through weeks or months. The lacteal secretion is suspended in the affected lobules. The milk-ducts are narrowed or closed. Pus may escape externally by ulceration through the skin, sometimes resulting in fistulæ, or it may penetrate one of the larger ducts and be discharged with the milk.

Subglandular cellulitis can seldom be detected with certainty until suppuration has taken place. The general symptoms are the same as those already enumerated. The pain is deep-seated and aching in character. The breast is greatly enlarged, though smooth and regular in outline. The axillary glands are usually swollen and tender, and movements of the arm which involve contraction of the pectoral muscles are exceedingly painful. The integument may become œdematous, but it is not congested or sensitive. If the accumulation of pus is considerable, the gland is lifted away from the chest-wall and floats upon the liquid base.

Attacks of mastitis are generally ascribed to cold, to blows or bruises upon the breast, emotional disturbances, obstruction of the lacteal ducts, and to inflammation of the nipples, extending along the milk-ducts or extending by the lymphatics to the deeper tissues.

Circumscribed cellulitis, whether superficial or deep, does not necessarily arrest the secretion of milk, even if localized suppuration occurs. If the inflammatory action is general, lactation is suspended, but the function is not destroyed unless sloughing or adhesions should permanently injure the secretory structures.

Superficial cellulitis may sometimes be arrested, at the very commencement, by the application of the tincture of iodine to the inflamed spot, and it may otherwise be treated like threatened abscess in any situation. If an abscess should form notwithstanding efforts to avoid it, recovery will be hastened by early opening in a line radiating from the nipple.

Constitutional treatment is indicated in the severer forms—sometimes in all. Opiates are frequently required for the relief of pain; laxatives or cathartics may be necessary. If the temperature or pulse-rate should run high, veratrum viride or some other cardiac sedative may be advantageously employed. When the excessive secretion and the accumulation of milk aggravate the pain or increase the risk of suppuration by pressure from within, belladonna or phytolacca decandra may be cautiously and tentatively used. Quinine is a valuable remedy, and should be given in full doses. In some anæmic and feeble subjects, a liberal, tonic, and supporting regimen is necessary.

The local treatment of the subglandular variety consists in rest and support of the breast. For this purpose, as well as for compression—which should be reserved in this form of abscess until after the evacuation of the pus—adhesive strips, a roller or a three-tailed bandage, applied as the tact, judgment, and experience of the physician may suggest, will accomplish the object sought. Topical medication is useless. So soon as pus is detected by palpation or by the introduction of a long exploring-needle, a free exit must be afforded at the lower part of the breast.

The treatment of the glandular form of mastitis is more satisfactory. In addition to the general means above recited, local treatment is very important. Nursing the child from the affected breast should be at once prohibited, but the engorgement of the breast must be overcome by rubbing from the base toward the apex. To lessen friction, a little olive-oil may be applied to the surface. Some persons prefer camphor, on account of its reputed property of reducing the secretion of milk. The lips of a nurse who understands the art of "draw-

ing breasts," applied over and around the nipple, will materially aid the process of expression. Repetition of this procedure, probably twice daily for several days, will be required.

The breasts should be supported and compressed either by skilfully applied adhesive strips, a bandage, or the compressed sponge. The topical use of belladonna is serviceable. Dry cold is recommended, though warm applications are, perhaps, generally preferred. If, however, despite well-directed efforts, suppuration should occur, so soon as any accumulation of pus can be made out, it should be evacuated.

It is well, in opening and treating mammary abscesses, to observe antiseptic precautions. *James B. Baird.*

1 Barker: The Puerperal Diseases.
2 Lusk: Science and Art of Midwifery.
3 Barnes: System of Obstetric Medicine and Surgery.
4 Galabin's Midwifery. 5 Playfair: System of Midwifery.
6 Parvin: Science and Art of Obstetrics.
7 Landis: Management of Labor.
8 Parvin: Gynæcological Transactions, 1880, vol. v.; and Barker: The Puerperal Diseases.
9 New York Medical Journal, December 15, 1883.
10 Ibid., February 16, 1884
11 Leishman: System of Midwifery.

PUERPERAL FEVER. Definition.—This malady may be defined as a continued fever following confinement. The opinion of the majority of pathologists of to-day is, that puerperal fever is produced by sepsis. An immense amount of labor is being done at present to elucidate and define the nature of this septic cause.

The type of the disease varies greatly, consequently its manifestations possess a wide range. This range covers, according to recent authors, the following conditions: *puerperal metritis; metro-peritonitis; purulent infection, or pyæmia; puerperal septicæmia; puerperal diphtheria* (Garrigues).

Etiology.—The special sources of sepsis are retained portions of the secundines, the hands of the physician, midwife, or nurse, instruments and sponges, and other puerperal-fever patients.

Among predisposing causes may be enumerated long-continued mental depression, blood-poverty, and an unknown epidemiological influence. The writer inclines to the belief that the accumulation of fæces, with its accompanying ptomaïnes, in the colon, so often found in lying-in women, may contribute to the development of this malady. The blood of puerperal-fever patients is profoundly affected. Women with fæcal accumulations in the colon possess a copric blood, which is, possibly, fertile soil for the puerperal sepsis.

Morbid Anatomy.—The autopsy reveals the almost innumerable lesions following sepsis. When death has resulted in a few hours after the septic invasion, before the coarser pathological changes can have developed, the ravages of the morbid germ can be detected in the "beginning inflammation in most of the tissues, such as cloudy swelling, and in the granular infiltration and disorganization of the cellular elements" (Playfair). A profound alteration in the blood is also found, as a great increase in the white corpuscles, an increase in the fibrin and extractive matters, and a decrease in the red blood-cells. The blood also contains an excess of urea and of carbonic dioxide.

Generally, in post-mortem examinations after every form of puerperal fever, there are found lesions of the genital tract, in the shape of lacerations which present an unhealthy appearance, their edges being œdematous and ragged. The endometrium is commonly found in a gangrenous condition. The solutions of continuity found in the vulva, vagina, and uterus present the sources of entrance of the morbid germ; hence this malady is found more frequently in primiparæ than in multiparæ.

At the vulvar orifice these wounds undergo such a change that they present an appearance of ulceration, denominated "puerperal ulceration."

These ulcerations sometimes extend up the vagina and even into the uterus, are surrounded with much œdematous infiltration, and are named by Virchow "malignant internal puerperal erysipelas."

These extensive ulcerations are denominated, according to their site, "puerperal colpitis" or "puerperal metritis."

The pathological changes seen in the uterine parenchyma, in the veins, lymphatics, and pelvic cellular tissue, are often extreme. Pus is often found in the uterine lymphatics and veins, showing the existence of metro-lymphangitis or metro-phlebitis. The pus is oftenest found at the tubal insertions, and is carried along the lymphatics into the pampiniform plexus of veins, thus explaining the frequency with which para- and peri-metritis complicate metritis.

The peritoneum is nearly always affected. Congested patches only may be noticed. Usually the whole membrane is involved, the intestines being bound down with adhesions, thus forming pockets containing pus, with flaky lymph in greater or less quantities. Pericarditis, pleuritis, and meningitis may be seen also—in short, all the serous membranes may be found in various stages of inflammation. The joints may be invaded by fluid, serous or purulent.

To epitomize: First, in the inflammatory form of puerperal fever will be found lesions confined chiefly to the pelvic tissues and to the peritoneum. Second, in the pyæmic form will be found phlebitis, with metastatic abscesses in any of the organs, as the ovary, liver, lung, kidney, spleen, eye, muscles, and connective tissue. Third, in the septicæmic form lymphangitis is the chief morbid feature of interest.

The pathological changes are the most pronounced in chronic cases.

Symptomatology.—There is a greater latitude in the symptoms of this malady that in those of any other disease.

The only constant symptoms in all forms of puerperal fever are the *facial expression* and the *pulse*. The symptoms most conspicuous in any one form of this disease may be only feebly marked or wholly absent in the other forms. Reflection indicates at once that, the pathological conditions of puerperal fever being so varied, there must necessarily be a great diversity of symptoms manifest in this terrible malady. Hence any description of the symptoms intended to cover all cases must be incomplete. The following may suffice to give a very brief clinical history of the progress of a case of puerperal fever:

The disease is ushered in, within from two to four days after delivery, with a chill—varying anywhere between the two extremes of a succession of slight cold waves, originating apparently in the spinal cord, to a severe prolonged chill lasting an hour or longer. In the majority of cases this chill-invasion is insidious; in some cases it is wholly absent. Following it there is an alarming increase in the pulse-rate—alarming because it is always present in this malady and at once indicates the gravest possibilities. It may vary from 100 to 150 or more beats per minute. Accompanying this rise in the pulse-rate is an elevated temperature, generally to 102°, and, in the severest cases, to even 105° or 106°. The countenance early becomes sallow and sunken, and has a most anxious expression. The skin is hot and dry. The lochia are greatly diminished or wholly suppressed, and the mammary secretion may be arrested. In many cases there is severe general cephalalgia, and oftentimes delirium is early developed. The absence, or a great perversion, of sleep is observed. The tongue is heavily coated early in the disease, and soon becomes dry and rough, and sordes appear on the gums and lips. Vomiting is often present, the ejecta being dark and of a peculiar odor. Tympanites, with much pain and tenderness aggravated by pressure, soon presents itself—although peritonitis, with effusion, may arise without these abdominal symptoms. Diarrhœa is often present, the evacuations being horribly fetid. Jaundice may develop. The breathing is often short and hurried. Pneumonia, pleurisy, or pericarditis occasionally ensues. The urine is generally much diminished, and albuminuria often supervenes. In pyæmic cases, suppuration develops in the joints or in any organ of the body. When fatal, the disease terminates usually within a week. The patient dies from exhaustion.

The foregoing may be regarded as a condensed and, necessarily, an incomplete syllabus of the symptomatology of this disease. It seems expedient to give a more amplified description of symptoms met with in a great many different cases, arranged under the headings of the various systems of the human organism.

The Nervous System.—In patients about to develop puerperal fever will be noticed a condition (properly belonging to the nervous system) of fatigue, as though they had not yet recovered from the shock of labor. Later the characteristic anxious facial expression is always developed. A certain amount of indefinable nervousness and apprehension is nearly always present, and is often accompanied with præcordial distress. The absence of these symptoms is very noticeable in women who have no puerperal troubles. Headache soon develops in the majority of cases. It is *general,* and is not confined to any single region of the head—as the corona, occiput, or temporal region. Sometimes it is very severe; at others it is not complained of greatly.

Later, delirium often arises. At first it is characterized by the patient being dazed for several minutes upon waking, and unable to tell where she is, or to recognize her surroundings or her friends. Some cases present delirium early in the course of the fever, and it grows more and more pronounced until it is continuous. As the patient approaches the fatal issue, the delirium becomes low and muttering. In cases that recover, the cerebral nutrition is often at such a low ebb that the patient is continually possessed of hallucinations of vision and hearing. She sees all sorts of weird objects and sights that have no existence, and hears conversations that do not occur. This is a condition often seen in feeble patients with other diseases. In many fatal cases the intellect is singularly clear till within a few hours of death, when the low, muttering, lethal delirium sets in. Oftentimes the delirium is manifested only at night, alternating with intervals of consciousness. In such cases the contrast of the nurse's night report with that which the physician beholds in his patient in the morning leads him to suspect the nurse's accuracy of observation. Occasionally this intermittent delirium is very severe, bordering on mania.

Subsultus tendinum and carphologia are often developed in the later stages of the disease. The hands and lips may tremble when they touch anything.

There is generally a chilliness preceding the rigor which commonly ushers in puerperal fever. The rigor is often absent, or so slight as to escape observation, or is attributed to some fugitive cause. In other cases the rigor is repeated and very severe, and this is especially so in the pyæmic form. Sometimes rigors, with exacerbations of the general symptoms, are observed on the sixth or seventh day; D'Espinne attributed the occurrence of these to fresh accessions to the systemic infection from putrid pus in the peritoneal cavity.

Pain is generally a marked characteristic of peritonitis, though not an invariable one. It begins in the hypogastrium, and soon invades the entire abdomen. Sometimes the pain is slight. In some cases it is wholly absent, and yet peritonitis progresses to its inflammatory sequences, terminating fatally in the great majority of cases.

The Circulatory System.—The increase in the pulse-rate is always present, from 100 up to 150 and higher, often reaching an uncountable point before the demise. Acceleration of the pulse from transient causes, as the nervous excitement of the advent of the physician, mental annoyance, hot drinks, etc., is to be excluded from the important symptoms. An unaccountable acceleration of the pulse is always alarming in recent puerperal patients. A pulse above 130 beats per minute is always of the gravest import. The arterial tension is always lowered, as is shown by the weak, thread-like pulse. If the pulse-rate diminish, and a corresponding improvement obtain in other respects, it augurs well.

The Respiratory System.—The breathing soon becomes short and hurried. If tympanites develop, the rate of respiration is greatly accelerated. Later, as the heart grows weaker, the patient becomes cyanotic. Toward the last the breath has a heavy, sweetish odor. The respirations may be from 50 to 60 or more per minute. Often pneumonitis, or pleuritis, or pericarditis may develop. In the cases of purulent infection embolic infarctions supervene in the lungs, pleura, or pericardium, often followed by suppurative inflammations terminating in abscesses. In cases of peritonitis, when the tympanites is enormous the breathing is wholly thoracic, the patient lying on her back with her knees drawn up.

The Alimentary System.—The tongue at first presents no distinctive character, but later it becomes furred. Soon thereafter it is covered with a heavy, deep fur—white or brownish. Still later it becomes dry and rough, and is often indented with the teeth. Toward the last the tongue, gums, and lips are covered with sordes.

Thirst is generally great. The more the cutaneous transudation prevails, the greater will be the thirst. Its absence is a favorable symptom.

Vomiting does not often occur early. The ejecta are dark, like coffee-grounds, and are occasionally very offensive. Sometimes they are feculent. It often continues to the end, or it may be present only a short time.

Diarrhœa is of frequent occurrence. Occasionally it is profuse and uncontrollable. In mild cases it is often salutary. When the case is severe, and the diarrhœa increases and becomes more and more offensive, the outlook is gloomy. The more malignant the case, the earlier will the diarrhœa develop.

Tympanites appears betimes. Sometimes it develops within twenty-four hours after the initial chill; at other times it supervenes much later. It may arise from digestive perversion or from peritonitis. Often it is extreme, causing the greatest distress, and persisting to the end. The meteorism is most marked in cases of peritonitis. The muscular coat of the intestine becomes paralyzed and the distention of the intestine is enormous. The patient occupies the dorsal decubitus, and often cannot bear the weight of the bedclothing. Toward the end the distention, with its pain and tenderness, often diminishes, and thus would mislead the physician but for the ominous pulse and facies.

Occasionally constipation exists, and is inordinately rebellious.

The Renal System.—The urine is diminished in quantity, sometimes almost to the point of its total suppression. Its watery element is deflected through the cutaneous and alimentary channels in the forms of sweat and diarrhœa. Consequently it is very dark from concentration, often having the appearance of blood. Albuminuria is often present.

The Cutaneous System.—As a rule the skin is dry and hot, but later in the disease it is bathed in sweat. An occasional case is seen in which sweating is continuous throughout; this Blundell regarded as a distinct variety of puerperal fever, calling it "hidrotid fever." Cases occur in which a rigor, a hot stage, and sweating quickly follow each other; they may at first be regarded as malarial, but as the case progresses they soon declare their malign meaning. Often the sweat possesses a peculiar odor. Toward the close the skin is always cold, damp, and clammy. Now and then a peculiar yellowish discoloration of the skin is observed. Jaundice is occasionally developed. Rarely, transient patches of erythema are seen on various parts of the skin. An eruption of sudamina commonly results from the profuse sweating. Occasionally a scarlatinoid eruption is seen.

General and Special Symptoms.—*The Temperature.*—The temperature is always elevated, and is characterized usually by a morning remission and an evening rise, or exactly the reverse. In mild cases it rises to 102° on the second or third day. The sooner after delivery that it is observed, the more alarming does it become. The fugitive rise of temperature from mammary and alimentary irritation will be borne in mind while investigating the possible advent of puerperal fever. In fulminant cases the temperature may not rise above 100°, while in comparatively mild cases it may rise to 104°, or even higher. In large remissions of temperature, not in

collapse, the outlook is favorable. In severe cases the temperature rises at once to 104°, or even to 106°, and it is subject to sudden remissions and exacerbations.

The Lochia.—The discharge is often diminished, and in a certain proportion of cases is wholly suppressed. When not entirely suppressed it becomes characteristically fetid. There are cases in which it is more than usually abundant.

The Mammary Secretion.—Rarely, the flow of milk is abnormally large. Diminution, even to the disappearance, of this secretion is the rule. The breasts often become hard and painful.

The Generative Organs.—Uterine tenderness on pressure, after the second day increasing very markedly, indicates the development of the endometritis which precedes general metritis and systemic infection. The fundus can easily be felt through the hypogastrium, and when its tenderness is physiological—*i.e.*, when it arises from massage to facilitate placental expulsion—Priessnitz compresses will cause its disappearance.

After-pains continuing or arising after the third day in multiparæ are suspicious of sepsis. When they are well marked in primiparæ they show incomplete uterine contractions, which may be followed by infection or by hæmorrhages.

The vulva may become œdematous, and be the seat of diphtheritic ulcers.

Localized Inflammations and Suppurations develop in the pyæmic forms. They may occur in any joint, and are always accompanied by the usual subjective and objective symptoms characterizing such conditions. Large caverns of pus may develop in the muscles and in the connective tissues. Any organ may be the seat of abscess-development.

Prognosis.—Until the patient is manifestly improving, all attempts at a reliable prognosis are extremely problematical. When the disease begins early—within the first thirty-six or forty-eight hours—the case will generally be a severe one. When the chill is repeated at intervals, being preceded by improvement, the danger lies in the possibility of the repeated infections fatally exhausting the patient. The general condition of the patient signifies much—the better it is at the time of the attack the better are the chances of recovery. In pyæmic cases the prognosis is invariably gloomy. Para- or peri-metritis followed by abscesses may result in chronic invalidism, lasting months or years.

Treatment.—*Prophylactic.*—This is of prime importance. Mindful of the channels of infection, the physician is enabled to avoid sepsis in the majority of cases. Before touching the patient the hands should be thoroughly disinfected by rinsing in a carbolized solution of the strength of 1 to 20, or by anointing with carbolized vaseline—1 to 20—after they have been well washed in hot water and castile-soap, particular attention being paid to the finger-nails. All instruments and sponges used in the genital tract should be carefully carbolized. The careful and complete delivery of the secundines is absolutely indispensable.

When lacerations exist, they should be carefully cleansed by irrigation with a 1 to 40 solution of carbolic acid and dusted over with iodoform.

General Treatment.—The source of infection should be determined if possible, in the hope of arresting further accessions to the sepsis. In most cases it lies in the vulva and vagina. When the attendant is convinced that it arises from the uterus, the intra-uterine douche of an antiseptic solution should be promptly used. Weak solutions of carbolic acid, corrosive sublimate, iodine, or Condy's fluid, can be used through a double-current catheter every eight, twelve, or twenty-four hours. Corrosive sublimate is much lauded for its germicidal properties, and can be used in the 1 to 3,000 solution. It is dangerous, cases being recorded in which death through toxic nephritis has followed its use. After the intra-uterine douche, a bacillus containing 50 to 100 grains of iodoform should be introduced into the uterine cavity. These local applications should be used so long as they are of advantage. After the use of the intra-uterine antiseptic douche, the temperature usually falls—in some cases from three to six degrees—and often this decrease in temperature is final. More frequently, however, it is followed by another rise, due to new absorption, and the repetition of the douche is followed by another defervescence. Thus, cases will be found in which the repeated fall of temperature and its later rise after the douche will extend over many consecutive days. Local treatment is more effective and direct than general medication.

Pain.—For this symptom, opium or its derivatives can be used. It must be given in quantities sufficient to allay suffering, subdue restlessness, and induce sleep. Laudanum in poultices over the abdomen often proves grateful. When opium cannot be borne, chloral hydrate or cannabis indica may be used. Two parts of extract of belladonna and one part of glycerine, thickly spread over the whole abdomen, often relieves the great tenderness found present with extreme intestinal distention. In peritonitis hot fomentations are often singularly grateful. Turpentine stupes are also of great value. Collodion over the whole abdomen is decidedly useful in alleviating the pain of this complication.

Fever.—For this manifestation, quinine is of great service. It should be given fearlessly and continuously—say, in ten-grain doses every four or six hours, until defervescence sets in; when head-symptoms follow its use, hydrobromic acid often allays them. The baleful effects of quinine on the stomach must be borne in mind. Warburg's tincture has been recommended for the purpose of lowering the temperature. Antipyrin has been recommended likewise. The theoretical objection to it—its cardiac depressing influence—deters many physicians from using it. Veratrum viride, in five-drop doses of the tincture hourly until the pulse falls below 100, afterward two or three drops every second hour to hold the pulse steadily below 100, is greatly praised by Fordyce Barker. Aconite may be similarly used. Both of these remedies are contra-indicated when the vital powers are much prostrated, as is indicated by a weak, thready pulse and cold extremities. Cold sponging in sthenic cases has its advantages.

Vomiting is often uncontrollable. Champagne or raw brandy will sometimes arrest it. Sulphate of magnesia, in thirty- or forty-grain doses in tepid water every hour, or every second hour, till the bowels move, often arrests vomiting. Three to five grains of calomel every three or four hours to purgation will sometimes accomplish the same end. The tendency to diarrhœa in this disease is not to be forgotten, and its artificial production must be undertaken with caution. In persistent vomiting rectal alimentation can be resorted to.

Tympanites may often be relieved by the use of the rectal tube every three or four hours. It usually manifests itself first in the transverse colon, and can be detected by a bulging at the scrobiculum cordis. The use of sulphate of magnesia or of calomel to catharsis often relieves distention. Placing the patient on her face, with her thighs drawn up under her abdomen, often causes enormous expulsions of gas with great relief (Parkes). Turpentine internally is sometimes of marked advantage.

Diarrhœa often occurs in acute cases toward the close of the scene, and can be restrained by no remedy. In chronic cases it is frequently a prominent symptom, and may be checked by the use of the tincture of the perchloride of iron in twenty- or thirty-minim doses.

Food and Stimulants are to be used frequently and in small quantities. Concentrated beef-tea, milk, eggs, brandy, and champagne are the main stays in supporting the patient until the effects of the poison are worn off. The most abundant supply of fresh air compatible with safety should be secured. *James H. Etheridge.*

PULASKI ALUM SPRINGS. *Location*, Pulaski County, Va.

Post-office, Dublin, Pulaski County, Va.

Access.—By the Norfolk & Western Railroad to Dublin; thence by stage to the springs, twelve miles.

ANALYSES.—These are, according to Walton, very similar to the Rockbridge Alum Springs of Virginia.

The springs are located at the base of Walker's Mountain, on the bank of a creek, in the extreme southwestern part of Virginia, amid the picturesque scenery of that region. There is a hotel at the springs.

G. B. F.

PULEX PENETRANS, chigoe, chiggre, jigger, sand flea, rhynchoprion penetrans, is a minute parasite abounding in the West Indies and tropical regions of the Eastern and Western continents. The female alone attacks man, and does so for the purpose of depositing her eggs. She penetrates the thin skin between the toes or about the toe-nails, and then swells up to the size of a pea, forming a bag of eggs; this causes much irritation, which often results in suppuration, followed by open ulcers. This is generally regarded as a true flea; it lives in dry, sandy places, and multiplies prodigiously.

When the chigoe is recognized under the skin, it should be carefully removed, or if suppuration has already occurred, the parts should be washed with solutions of carbolic acid, carbolized oil, etc.

Charles E. Hackley.

PÜLLNA is a village in Bohemia, in which are several springs of a bitter water, well known and frequently employed in this country as a mild and efficacious laxative. The water resembles closely that of Hunyadi Janos, but is milder and less certain in its action.

The composition of the water varies within certain limits, but not sufficiently to be a matter of any particular importance. The following is the analysis given in the U. S. Dispensatory (15th edition, 1883), after Struve. One pint contains:

	Grains.
Magnesium carbonate	6.406
Calcium carbonate	0.770
Magnesium chloride	19.666
Potassium sulphate	4.800
Sodium sulphate	123.800
Magnesium sulphate	93.086
Calcium sulphate	2.600
Calcium phosphate	0.003
Silica	0.176
Total	251.307

The dose of Püllna water is one or two glasses in the morning as a laxative; for its so-called alterative effects it may be taken in ounce or half-ounce doses, several times a day. The water is exported exclusively, and there are no accommodations for visitors at Püllna. *T. L. S.*

PULSATILLA, U. S. Ph. (*Anémone Pulsatille* or *Coquelourd*, Codex Med.). "The herb of *Anemone pulsatilla* Linn., and *Anemone pratensis* Linn., and of *Anemone patens* Linn., *var. Nuttalliana* Gray, Order *Ranunculaceæ*, collected soon after flowering" (U. S. Ph.). The Anemones are perennial herbs, with flowers having the general structure of buttercups, but without petals, the place of the corolla being taken by a showy calyx of large colored sepals (purple, blue, white, etc.), while the calyx is simulated in some instances by a conspicuous involucre. Stamens numerous, the outer sterile; pistils also many, small, simple, covering the convex receptacle, and ripening into one-seeded achenes, styles persistent, often long and plumose. *A. pulsatilla* is a low hairy plant, with a short, thick stem, and a cluster of doubly pinnate and dissected radical, hairy leaves. Flowers solitary on hairy scapes, two or three centimetres across, with the involucre some distance below the calyx. It is a native of England and Northern Europe. *A. pratensis* has the involucre near the calyx, and a less open flower; it grows in the southern part of Europe. *A. Nuttalliana* is a native of North America.

The leaves of Pulsatilla have a very sharp, stinging taste, like that of the buttercups, and but little odor; they grow insipid by age, and should not be kept more than one year.

COMPOSITION.—The Anemones, in common with buttercups and probably some other *Ranunculaceæ*, contain a very pungent, volatile, *oil-like principle*, which can be separated by distillation with water. Upon long standing it separates two solid substances, *anemonin* and *anemonic acid*. The former is a colorless, crystalline, neutral substance of but little taste when cold, but intensely pungent when melted. It is but slightly soluble in cold alcohol, ether, or water; more so in those liquids when hot. This is the active principle. *Anemonic acid* is a white, amorphous, insoluble substance, of neither odor, taste, nor medicinal properties.

FIG. 3130.—Anemone Pulsatilla. (Baillon.)

ACTION AND USE.—Pulsatilla is an old remedy, with a good many reputed empirical powers. It has had a reputation in chronic eruptions, syphilis, "ophthalmia," amaurosis, nasal and bronchial catarrh, etc. It is now sometimes given in dysmenorrhœa, whooping-cough, asthma, etc., with supposed advantage. It is extensively used in homœopathic practice. Anemonin is an active poison, reducing the heart-beats in number and strength, and reducing the number of respirations. Collapse, paralysis, stupor, and convulsions have been observed after its administration.

Dose, of Pulsatilla one or two decigrams (gr. ij. ad iij.); of Anemonin, one or two centigrams (gr. $\frac{1}{6}$ to $\frac{1}{3}$).

ALLIED PLANTS.—A number of Anemones are favorites in the flower-garden, others are well known and pretty wild flowers. *A. nemorosa*, the wind-flower, is reputed to have properties similar to the above. See ACONITE for the order.

ALLIED DRUGS.—There is a family resemblance in the

actions of a good many of the *Ranunculaceæ*. *Anemone, Ranunculus, Adonis, Clematis, Delphinum*, etc.; *Symplocarpus* (Skunk Cabbage), and *Arisæma* (Indian Turnip) have a similar acrid, benumbing principle.

W. P. Bolles.

PULSE, ARTERIAL. With each systole, the left ventricle of the heart propels into the already full aortic system an additional volume of blood. The time occupied by the influx of this volume of blood into the aorta is the period from the opening of the semilunar valves until the beginning of relaxation of the ventricle. The same volume of blood escapes from the arterial system through the capillaries in the time occupied by one entire cardiac cycle, of which the period of influx is only a part. Hence only a part of the volume of blood thrown into the aorta escapes during the time of its influx; for the remainder room is made for a while by a dilatation of the (yielding) arteries. This dilatation takes place first in the root of the aorta, is quickly propagated along the arterial tree in the form of a wave, and is immediately followed at each point by a contraction of the (elastic) arterial wall. This alternation of dilatation and contraction of the arterial tube is called the pulse.

The *velocity of transmission of the pulse-wave* differs not only in different vessels, but in the same vessel under different conditions. For peripheric arteries, the average rate was found by Weber, 9.240 metres per second; Landois determined it 6.431 m. for the lower extremities, and 5.772 m. for the upper; Grunmach 6.6 m. in the direction of the carotids, 9 m. in the upper extremities, 11 m. in the lower; Moens found an average rate of 8 to 8.5 m.; Grashey, 8.53 m. "The velocity of the pulse-wave normal to the individual is closely preserved under ordinary physiological variations of the circulation," and the pulse-rate has no notable influence over it (Keyt[1]). It is much slower in young children than in adults, and increases with increase of age (*Id.*) Rise of blood-pressure increases the rate of transmission, and *vice versa*. Morbid processes which affect the diameter, thickness, and elasticity of the arteries, affect also the velocity of the pulse-wave, according to known laws.* Grunmach[3] saw it diminish in most cases of valvular disease of the heart, according to the degree in which the functional power of the heart was lowered. Lead-poisoning, digitalis, and caffeine increased it parallel with the increased arterial tension; chloroform, chloral, and morphine diminished it.

The interval between the heart-beat and the radial pulse is commonly .15 to .2 second; it is altered in some diseases, notably lengthened in mitral, shortened in aortic insufficiency. In the radial artery, the pulse arrives about one-fifteenth to one-tenth second later than in the carotid; Czermak states the difference as .094 second. Landois found the difference in time between femoral and dorsalis pedis, .154 second; between axillary and radial, .087 second; between axillary and dorsalis pedis, .212 second. Keyt[4] gives the mean time-difference between carotid and radial as .0714 to .0888; between carotid and femoral, .050 to .0909; between carotid and posterior tibial behind the malleolus, .125 to .166 second. Moens observed, for the latter, .167 to .178 second.

The pulse is examined by means of palpation, inspection, auscultation, and by the graphic method (sphygmography). Apart from murmurs produced in the arteries by disease of the walls, and from sounds and murmurs transmitted from the heart (which are not within the province of this article), there may be heard in some arteries sounds and murmurs produced by the pulse itself. Wolff,[5] who appears to have been the most expert auscultator of the pulse, recommending practice on the brachial artery in the bend of the elbow, says: "With the common normal cubital pulse of persons of middle age [in lean individuals, especially convalescents], there are heard three sound-like murmurs, coalescing when the stethoscope is lightly applied, but more or less distinct, and therefore shorter, upon closer approximation to the artery; their strength and *tempo* correspond to the size and sequence in time of the three pulse-strokes and the three large elevations of the curve." In the pulse of the aged, the first and second murmurs only are heard; in the dicrotic pulse the first and third are heard distinctly. The radial pulse has likewise been heard by Wolff, but other auscultators have been less successful. Thus far, the auscultation of these murmurs has not added to our knowledge of the pulse.

Inspection of the skin over superficial arteries sometimes reveals the existence of visible pulsation in parts where normally no pulse is seen. During excited action of the heart, in cardiac hypertrophy, in vaso-dilatation of a part, the pulse of some arteries usually concealed becomes visible, as in the well-known throbbing of the carotids and temporals in congestion to the head, the phenomenon of epigastric pulsation, etc. Bettelheim[6] calls attention to visible pulsation of the brachial artery as frequently of diagnostic value. Under normal circumstances it is often, but not always, seen in old people, only now and then (feebly) in emaciated persons, and after violent exercise of the muscles of the arm; when present under other conditions it indicates aortic insufficiency, arterio-sclerosis, or hypertrophy of the heart.

PALPATION.—The act of feeling the pulse was in danger of being lost in the present century, when improvements in physical exploration in other directions—percussion, auscultation, thermometry, etc.—diverted the attention of the physician from the pulse, and the traditional habit of placing the fingers upon the patient's wrist began to have little result beyond counting the number of pulsations in a minute. The recent application of accurate experimental methods to the investigation of the pulse has been the means of once more educating the touch to a better appreciation of the movements of the artery, to a nearer approach to the *tactus eruditus* of old.

Palpation of the pulse is performed by placing the tips of at least two, better three, fingers close together in a line upon the arterial tube, and with a certain practised elasticity of touch, the fingers following or yielding to the movements of the arterial wall. The (radial) artery should, moreover, be put in a favorable position by relaxing the tissues about it, holding the forearm midway between pronation and supination, both hand and forearm being gently flexed. By this means are detected differences as to (1) frequency and rhythm; (2) degree of resistance to pressure, compressibility; (3) magnitude; (4) celerity; and (5) secondary waves.

Pulse-rate.—The frequency of the pulse depends solely upon the movements of the heart, each pulse-beat representing a contraction of the left ventricle. The normal pulse of the adult male varies from 60 to 80 beats in the minute; the statement that the mean of numerous observations in many individuals lies between 71 and 72 is of no value, because the range of individual variations is very great. The range of the pulse-rate in females is even greater, not a few having an average pulse of more than 80 beats, and some of less than 60; the majority show a higher frequency than males. In children the pulse is more frequent: At birth, 128 to 144; in the first year of life, 120 to 130; at the age of ten years, 90. In old age the pulse is usually more frequent than 72, but often also much rarer, between 50 and 60. The pulse-

* The rate of transmission of waves in elastic tubes can be calculated by the formula of Moens,[2] $Vp = 0.9\sqrt{\frac{g\,E\,a}{\Delta\,d}}$, in which Vp stands for the distance which the wave travels in one second, expressed in centimetres; g for the acceleration of gravity = 980.88 centimetres; E for the coefficient of elasticity of the tube (in grammes per square centimetre); a for the thickness of the tube in centimetres; d for the diameter of the tube in centimetres; Δ for the specific gravity of the liquid. Hence the velocity of transmission varies inversely as the square root of the specific gravity of the liquid; directly as the square root of the thickness and inversely as the square root of the diameter of the tube; and directly as the square root of the coefficient of elasticity of the wall. The first-named factor, Δ, can be disregarded in the case of the arterial pulse, since the specific gravity of the blood varies too little to affect perceptibly the rate of transmission. Keyt (l. c.) has arrived at similar results, and demonstrated some of them in cases of disease.

rate is higher in short than in tall persons.* Habitual pulse-rates below 56 and as low as 46 have been observed in healthy adults, but they are rare exceptions.

The pulse-rate varies somewhat with the time of day, independently of meals and movements, diminishing in the forenoon, rising in the afternoon, sinking during the night, and rising in the morning. The first maximum is reached between 8 and 11 A.M., the second between 6 and 8 P.M.

The frequency of the pulse is increased by the activity of the working organs: by muscular labor, by digestion (increased glandular labor), by psychical processes (emotions, pain, intellectual labor). Exposure to heat, and elevation of the body-temperature, raise the pulse-rate. Position (in accordance with the muscular labor involved) affects the pulse-rate, which is higher standing than sitting, higher sitting than lying. Guy[7] found the averages in adult males standing, 79; sitting, 70; lying, 67; with remote extremes, and the differences increasing with the frequency of the pulse. The differences are less marked in females, and in early youth. Graves states that in hypertrophy of the heart these differences disappear, and the same has been said[8] of pregnancy.†

Rise of arterial blood-pressure diminishes the pulse-rate, and, *vice versa*, a fall of blood-pressure increases the frequency of the pulse (Foster,[9] Mahomed[10]).‡

Tarchanoff recently studied and reported[29] the case of a young man who had the power of voluntarily accelerating the action of his heart, probably the only authenticated exception to the rule that the pulse-rate is not subject to the will.

Variations in rhythm are more accurately observed by instrumental means than by palpation, and will be described later.

Compressibility.—The degree of resistance to the finger depends partly upon the degree of elasticity of the artery, becoming greater with increasing rigidity of the tube, as in the aged; partly upon the blood-pressure. In order to estimate the mean blood-pressure (not only during, but also in the intervals between the beats) it is necessary (1) to place the (three) fingers lightly upon the vessel and with them move the integument over it in a transverse direction, rolling, as it were, the artery under the fingers (observation of the size of the artery apart from its distention by the pulse is a very important and much neglected function of palpation; a pulse of high tension may be witnessed in a contracted artery as well as in a large artery), and (2) with the finger nearer the heart to compress the artery until the pulse is no longer felt by the distal fingers. When the mean blood-pressure is high, the artery is felt distinctly as a cord; deeper pressure does not readily suppress the pulse, but makes the impact of the wave more distinct. In low tension, the artery is flattened by moderate pressure and the pulse is easily suppressed. The exact estimation of the degree of resistance by palpation is difficult and requires great attention, chiefly because the finger takes cognizance, not of the compressibility of the artery alone but at the same time of the rigidity of the vessel, its size, and the amplitude of the pulse-wave. More accurate results are obtained by instruments of precision, as Waldenburg's *Pulsuhr*,[11] and v. Basch's *Sphygmomanometer*;[12] indirectly, the sphygmograph also indicates the tension of the arterial wall.

The other qualities of the pulse which can be perceived by the finger are better studied with the help of the sphygmograph, whose lever magnifies the movements of the

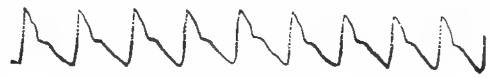

FIG. 3131.

FIG. 3132.

FIGS. 3131 AND 3132.—Normal Tracings of the Radial Pulse by Marey's Sphygmograph. (Breguet.) Pulse-rates, 82, 88.

artery and registers them, on a surface travelling at a uniform rate, in the shape of a series of curves. (For de-

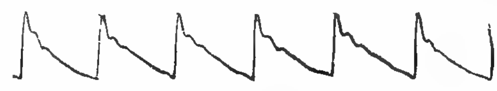

FIG. 3133.—Normal Tracing, Radial, by Pond's Sphygmograph. Pulse-rate, 56.

scription of the instruments and their use, consult article Sphygmograph.)

FIG. 3134.—Normal Tracing by Burdon-Sanderson's Modification of Marey's Sphygmograph. Pulse-rate, 72. The above, and subsequent tracings illustrating this article, unless otherwise specified, are reproductions of originals in my possession by photographic means only, without drawing or retouching. Those by the Burdon-Sanderson instrument (which has a rapid movement and magnifies more highly than the other instruments used) were taken and kindly furnished by Dr. William Townsend Porter, late Senior Assistant to the St. Louis City Hospital. When the artery is not designated, the tracing is to be understood as that of the radial artery.

SPHYGMOGRAPHY.—*The Normal Pulse-curve.*—As the artery dilates, the lever of the sphygmograph rises rapidly and marks upon the recording surface a *line of ascent* or *up-stroke* (Fig. 3135, *ab*), which is very steep, almost vertical; at the end of the dilatation the lever falls, marking a *line of descent* or *down-stroke*, *ba'*, which makes a well-defined acute angle, *apex*, *b*, with the line of ascent. This line of descent is sloping, and is interrupted by several secondary elevations. The most important of these, rarely absent, divides the line of descent into two nearly equal parts, the upper half terminating in a more or less well-marked depression, the *diastolic notch* of Burdon-Sanderson (Mahomed's aortic notch, Wolff's *grosse Incisur*), *e*, which is succeeded by a new rise of the lever marking the *dicrotic elevation*, *f*. The line of descent is further interrupted by minor elevations, the first of which precedes the dicrotic elevation, hence *predicrotic wave*, *d*, and is discernible in every well-written normal curve, while those which succeed the dicrotic wave are commonly faint or may be wanting.

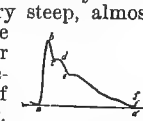

FIG. 3135.—Normal. Pulse-rate, 53. (Pond's.)

These divisions of the tracing express the events occurring in the movement of the arterial wall. The beginning (*basal point*) of the curve marks the opening of the aortic valves, the line of ascent expresses the influx of blood into the arterial tube. This line is not perfectly straight; the lever rises at first with increasing velocity and arrives at the apex with lessening velocity, tracing a line curved like a very long-drawn italic *f*. In some pathological curves the up-stroke is broken by one or more secondary (*anacrotic*, Landois) elevations; but this never happens in the normal curve. When the moment of greatest distention is reached the lever descends at once; the apex is a clean-cut angle. The descent, more gradual than the ascent, is due, of course, to the steady outflow of blood toward the capillaries. For a short time the

* So close is the relation of the average frequency of the pulse to the body-height, that various observers have been able to propose formulas for computing the pulse-rate from the height. According to Vierordt, the duration of each pulse increases by about .03 second with every increase of height of 1 decimetre. Rameaux, by theoretical reasoning, deduced the formula $n' = n\sqrt{\frac{d}{d'}}$ (n, n' denoting the pulse-frequencies, d, d' the body-lengths), which for adults gives computed pulse-rates agreeing very closely with the rates observed (Landois). Volkmann's formula, written in the same term is $\frac{n}{n'} = \frac{d'^{\frac{5}{9}}}{d^{\frac{5}{9}}}$

† Contrary to Hohl, who gave the pulse-rate of pregnant women standing, 94; sitting, 83; lying, 77 (Die geburtshülfliche Exploration, 1835).

‡ Landois makes the reverse statement (Lehrb. d. Physiologie, 2. Aufl., 1881, p. 142).

ventricle is held in systole ; at the end of this period, the ventricles relaxing, a small reflux of blood closes the aortic valves with a short snap, which starts a small positive wave, expressed in curves obtained from the largest arteries (carotid, axillary, femoral) by a small elevation below the apex. This wave is lost before it reaches the radial artery. In the radial trace there occurs, nevertheless, a predicrotic wave which is commonly explained * as the first, and therefore largest, of a series of wavelets due to elastic oscillations of the tense arterial wall (*Elasticitätselevationen*, Landois).

The dicrotic wave owes its origin to a different cause. The cardiac systole communicates a progressive movement to the blood in the aorta, which, in virtue of inertia, continues a short time after the closure of the aortic valves; a rapid lowering of the blood-pressure in the root of the aorta results. The contraction of the arterial wall, therefore, drives the blood, not only in the direction of the capillaries, but also, for an instant, toward this point of less pressure : a momentary reflux of blood upon the (closed) aortic valves ensues, which, rebounding, starts a positive wave (of recoil, *Rückstosswelle*, Landois ; *Schliessungswelle*, wave of closure, Moens) that is expressed in the pulse-curve by the dicrotic wave. If time be given before another cardiac systole repeats the cycle of events, the second half of the down-stroke may show a (smaller) second wave of recoil, as well as some elastic elevations. The elevations occurring in the line of descent are known as *catacrotic* elevations (Landois).

In the normal radial curve are always seen at least three distinct elevations : the primary wave (percussion-wave, Mahomed †) or apex, the predicrotic (tidal, Mahomed), and the dicrotic wave ; and, hence, disregarding the lesser oscillations which may follow, the normal curve is spoken of as " tricrotic." The relative size and position of these waves depend upon the conditions of the circulation, viz., the force of the heart's contraction and the amount of blood thrown into the artery, the tension and elasticity of the arterial wall, and the freedom of the distal outflow. According as these conditions vary the form of the curve is modified.

Amplitude.—The excursions of the lever, *i.e.*, the dilatation of the artery, may be greater or less, depending (1) upon the volume of blood propelled by each systole, and (2) upon the ratio of propelling force to resistance of the arterial wall. (The magnitude of the pulse-curve has, of course, no direct relation to the size of the vessel, which may be small [contracted] or large [expanded] and which must be *felt*, for the sphygmograph gives no indication of its diameter ; it must also be remembered that a superficial artery gives an ampler tracing than one covered by thicker layers of tissue.) A well-filled ventricle is indicated by great amplitude of curve ; but if the ventricle pumps only a small quantity of blood at each contraction, a low curve results. When the arterial tension is low, and the outflow toward the capillaries free, the lever falls deeply during the cardiac diastole, and a large curve results ; but when the outflow is obstructed, and the artery is already full and tense at the beginning of the systole, the curve *c. p.* is small. Thus we see a *large pulse* (*pulsus magnus*) in hypertrophy of the heart, in acute fevers (with low blood-pressure) ; a *small pulse* (*p. parvus*) in feeble action of the heart, in pulmonary obstruction, and in mitral insufficiency (imperfect filling of the left ventricle), and likewise in cases of high tension not overbalanced by increased power of the heart.

* Maurer [13] thinks that the predicrotic wave is caused by the closure of the aortic valves in all arterial pulses : that only the small wavelets sometimes added, most often between the predicrotic and the dicrotic wave, are elastic oscillations. I have followed the widely accepted interpretation of Landois without intention to decide this point.

† Mahomed conceived that the lever was thrown violently upward by the suddenness—" percussion "—of the systole ; that without this percussion the true apex of the curve would be reached only in the predicrotic elevation, which he therefore termed the tidal wave. This view is not supported by the measurements. A true percussion-stroke is but rarely seen, as in the radial curve in cardiac hypertrophy ; it is well marked in the aortic curves, Figs. 3149 and 3150, where the true apex can be readily distinguished, soon followed by the wave caused by the closing of the aortic valves. The use of Mahomed's terminology has therefore been avoided in the present article.

The height of the curve alone does not indicate (as is frequently stated) the volume of blood propelled at each systole ; this is more properly measured by the area enclosed between the curve and the base-line. A yielding artery (as in fever) is easily dilated, and a curve of greater height results than the same volume of blood produces in a tense or rigid artery. Increasing volume of blood will increase the height of the curve only so long as the force is great enough to propel it with such velocity as to overcome the increasing elastic resistance of the artery.[14] When, however, the arterial tension rises considerably, as by contraction of the minute arteries, the height of the curve no longer increases, the predicrotic wave is near the apex, the descent is delayed, and the dicrotic elevation is higher above the base-line ; *i.e.*, the pulse becomes *tardus* (see below) and the area of the curve is increased, though not its height.*

Fig. 3136.—(Pond's.)*

Celerity.—The rise of the lever may be more or less nearly vertical ; *i.e.*, the time occupied by the dilatation of the artery may be less or greater. It is very brief when the ventricle contracts with energy against a yielding artery ; the dilatation is slower when the heart is weak, or when the resistance in its front is increased by high blood-pressure, or by rigidity of the artery either in its entire course or at some point between the heart and the vessel under examination. In the former case, the up-stroke is very steep, and in a large pulse almost vertical, the apex very acute, and the first portion of the descent also steep ; the artery is quickly distended, and quickly emptied ; hence, the pulse is designated as *p. celer*, the *quick* or *short pulse*. When, on the other hand, the artery is tense or rigid, and does not yield readily, or when the force of the ventricle is small compared to the resistance in front, the pulse appears labored, the line of ascent is more slanting, the artery remains dilated for a time, because its recoil is likewise slow, the apex is blunted, the space between the lines of ascent and descent is widened, the first portion of the descent more gradual. This form of curve pictures the *p. tardus* of the older writers, the *slow* or *long pulse*.† Figs. 3160, 3162, 3177 to 3179, are examples of *p. celer ;* Figs. 3155 to 3157, 3181 to 3184, of *p. tardus*. In some soft pulses the ascent alone is slow, while the descent is rapid, as in Fig. 3137, B.

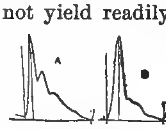

Fig. 3137.—A, pulse-rate, 68 ; duration of pulse, .867 sec. ; of ascent, .102 sec. B, pulse-rate, 80 ; duration of pulse, .752 sec. ; of ascent, .159 sec.

In judging of the steepness of the up-stroke (or down-stroke) the height of the curve must be taken into account ; with the same duration of the period of distention, the ascent must be more nearly vertical in a high curve than in a low curve, as is obvious from the diagram, Fig. 3138. The real criterion is the distance, in time, between the basal point and the apex ; see remarks on measuring the curves, below.

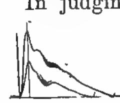

Fig. 3138.

The *Secondary Waves* in the down-stroke (catacrotic elevations) are subject to variations, both in their position and in their size. The conditions which influence them have been investigated by Marey, Landois, and many others. It has been shown that the *dicrotic wave*, in common with other waves, loses in distinctness with the distance from the heart of the artery examined, and

* In Fig. 3136, the area of curve A = 26.36 sq. mm., while the area of the higher curve B = only 19.97 sq. mm. ; the distention of the artery was greater in B, but it lasted longer in A. The area of C = 15.33 sq. mm., while the almost equally high curve D has an area of only 10.55 sq. mm.

† The classical terms, " quick " and " slow " pulse, are nowadays applied so universally, though illogically, to the frequency of the heart's beat, in place of the correct terms " frequent " and " rare," that Burdon-Sanderson proposes the words " short " and " long " as the English equivalents of *celer* and *tardus*.[16] Fig. 3137 shows two pulses of about equal amplitude, of which the rarer, A, is quicker (more *celer*) than B, the more frequent one.

that its distance from the primary wave (apex) is greater in the remote arteries than in those near the heart (because low waves are transmitted with less velocity than higher waves, Moens[16]). In the same locality the dicrotic wave is increased (1) by a short and energetic systole, (2) by diminished arterial tension, and (3) the wave is delayed by low tension (Moens[17]).

The development of *elastic elevations* or oscillations of the arterial tube is favored (1) by high tension, and (2) by perfect elasticity of the artery. Elastic waves are diminished or prevented (1) by low tension, and (2) by loss of elasticity in the vessel through disease of its walls, as in atheroma. Hence, in a vessel of normal elasticity, the size and number of the elastic elevations depend on the degree of tension of the arterial wall.

Tension.—From these propositions it follows that the character of the secondary waves is influenced largely by

FIG. 3139.—Normal Pulse of High Tension, 54. (Pond's.)

the blood-pressure. While it is not the function of the sphygmograph to measure, in any direct sense, the blood-pressure, the recorded curve gives indication of the degree of tension in the artery. A pulse-curve of high tension—the *hard pulse, p. durus* (Figs. 3139 and 3140)—is characterized chiefly by (1) early, distinct, and perhaps

FIG. 3140.—Normal Pulse of High Tension, 70. (Marey's.)

numerous elastic elevations, the predicrotic wave especially is well developed and near the apex, the descent of the lever appears delayed; (2) the dicrotic wave is small in proportion to the amplitude of the tracing; (3) the end of the first part of the down-stroke (the diastolic notch, *e*) is high above the base-line. In some strictly normal pulses of relatively high ("good") tension, the down-stroke forms an almost uninterrupted straight line from the apex *b* to the basal point of the next curve, *a′*, as in Fig. 3158. (Compare also Figs. 3144, 3155 to 3157, 3171 to 3173.)

In a curve of low tension—the *soft pulse, p. mollis* (Fig. 3141)—on the other hand, (1) the elastic elevations are small or absent, the predicrotic wave, if preserved, is comparatively low down in the tracing and small; (2) the dicrotic wave is likewise delayed, but well devel-

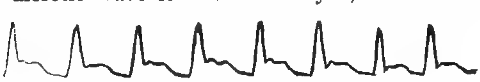

FIG. 3141.—Normal Pulse of Low Tension, 73. (Pond's.)

oped; (3) the first part of the down-stroke makes a steep descent, and forms a smaller angle with the second portion, thus _, and the diastolic notch is near the base-line. Very frequently these modifications coincide with the *p. tardus* and *p. celer* respectively, so that commonly a pulse of high tension is *tardus et durus*, the pulse of low tension *celer et mollis*. (Compare also Figs. 3147, and 3161 to 3170.)

Still further modifications are introduced into the form of the curve by the frequency of the beat. The period of dilatation of the artery, subject to the variations already spoken of (*vide* Celerity), is not influenced materially by the mere frequency of the beat; the period of descent bears no definite ratio to the time occupied by the ascent. A frequent pulse is commonly also a *p. celer*, but a rare pulse may also be *celer*. But when the ventricular systoles follow each other rapidly, the ventricle has not time to fill with the same amount of blood as when they occur at longer intervals; hence the amplitude of the curve is lessened as the pulse becomes more frequent. Moreover, in the frequent pulse the line of descent is cut off sooner by the rising wave of the succeeding beat; hence, while the period of ascent remains nearly the same, the period of descent is abbreviated; the shortening of the curve falls mainly upon the descent. Usually the rise in frequency coincides with a fall in blood-pressure, and *vice versa*, which is likewise expressed in the curve.

Measuring the Curves.—It is difficult for the beginner to estimate the described variations in the curve at sight; this art can be best acquired by practice in the actual measurement of tracings.

Curves of the same pulsation, drawn upon recording surfaces moving at different rates, assume great differences of aspect, while yet they record the same facts. This explains one of the difficulties in comparing tracings by different instruments. Curve A, in Fig. 3142, when traced on a plate moving with twice the velocity, assumes the shape of B; on a plate moving with half the velocity, the shape of C.

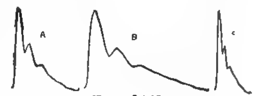

FIG. 3142.

The distance in time between two events of the pulse-movement can be measured on an abscissa parallel to the direction of movement of the recording surface—ordinarily parallel to the base-line of the curves—by means of ordinates drawn through the salient points of the curve. The direction of the ordinates is indicated by (parallel to) the directrix, "signal line," or "guiding line"—a line usually drawn at the beginning of a tracing by the style moving while the recording surface is still at rest (G *a*, Fig. 3143). This, in curves drawn by instru-

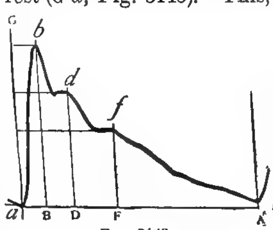

FIG. 3143.

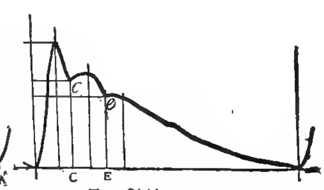

FIG. 3144.

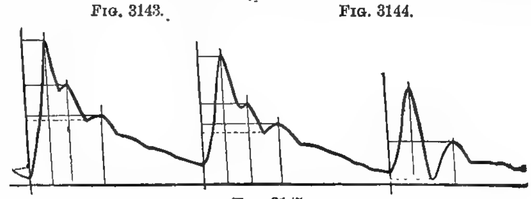

FIG. 3145.

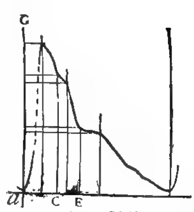

FIG. 3146.

FIG. 3147.

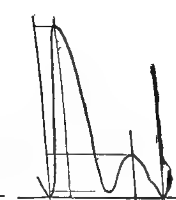

FIG. 3148.

FIGS. 3143, 3144, 3145 (Pond's); FIGS. 3146, 3147, 3148 (Marey's).—All magnified × 2. These curves were magnified (× 8) by the magic lantern, the abscissas and ordinates added, and the drawings reduced by photography (÷ 4).

ments the marker of which moves in a straight line (at right angles to the movement of the recording surface, as in Landois's angiograph, in Pond's and Dudgeon's sphygmographs) is itself a straight line, and vertical to the abscissa if the movement of the marker is exactly at right angles to the base-line, which is not always the case (*cf.* Figs. 3143 to 3145). In curves drawn by a lever that moves around a centre and in a plane parallel to the recording slide (as in Marey's sphygmographs, and in some of the tambour instruments, in Keyt's cardiograph, etc.) the guiding-line, and, consequently, the required ordi-

nate, is the arc of a circle whose radius is equal to the length of the lever. Figs. 3143 to 3148 are examples of such measurements. If the rate of movement of the travelling surface is known, the distance in time between two points in the curve can be measured by the distance in space between the points at which the respective ordinates cut the abscissa. In Fig. 3143 the time of distention of the artery, *a b*, is measured by the distance *a* B on the abscissa; the time between the apex, *b*, and the summit of the dicrotic wave, *f*, is measured by B F, etc. The relative height of the events on the curve above the base-line can similarly be measured on the guiding-line G *a* as an abscissa, by ordinates drawn upon it from the respective points parallel to the base-line.

Very accurate measurements are obtained by causing the lever of the sphygmograph to write on a surface fixed upon a vibrating tuning-fork. Landois also measured his curves under the microscope by means of an ocular micrometer. The writer has obtained good results by magnifying the curves registered on transparent slides by means of the magic-lantern.

It is not always easy to determine the exact location in the curve of the points to be measured. The readiest method to determine *d* and *f*, the summits of the predicrotic and dicrotic waves, is to draw parallel with a line connecting *c* and *e* (for *d*) or *e* and *á* (for *f*) a tangent to the elevation; the point of contact must be the highest point in the elevation (because the wave is superimposed upon the line of descent, which, but for this wave, would have been straight, or nearly so); but it is not always the point most distant from the base-line.

The period of ascent—indicating the duration of influx of blood into the artery—occupies only a portion of the ventricular systole. It is preceded by a period of less than one-tenth second from the beginning of the ventricular contraction to the opening of the aortic valves; and it is followed by a period of about .069 second from the time when the influx ceases until the closing of the aortic valves. Hence, the systolic portion of the curve (corresponding to the period between the first and second sound of the heart = about one-third second) begins before the up-stroke and terminates at some point in the down-stroke. This point, in successful tracings of the carotid pulse is found in the notch preceding the first secondary elevation, caused by the closing of the aortic valves. In the radial curve this wave is commonly absent; in the majority of cases (if not always—see foot-note on p. 86) it coincides nearly with the beginning (or the summit, Keyt) of the predicrotic wave; it is this point, not the so-called "aortic" or diastolic notch, that may serve to mark approximately the end of the cardiac systole.

The period from the beginning of the ventricular contraction to the opening of the aortic valves, the interval between the ascent of the cardiogram and the ascent of the pulse-curve—the *presphygmic interval* of Keyt[1] (*syspasis*, Garrod)—is said to have a mean duration of .087 second by Czermak; .10 to .11 second by Mosso; .073 by Rive; (only .02 to .03 by D'Espine?); .085 by Landois; about .08 sec. (with a pulse-rate of 75 per minute) by Keyt. The latter author made it the subject of extended investigation and demonstrated the importance of a knowledge of it in both physiological and pathological conditions. It is subject to considerable variation, and "varies inversely with the pulse-rate," "being shorter with frequent and longer with rare pulsations." Pathologically, the interval is lengthened, especially by slow ventricular contraction, by high arterial pressure, and by mitral insufficiency; shortened by quick contraction of the heart, by low arterial pressure, and by aortic insufficiency. In fever, with a fairly strong heart, the interval is short.

The duration of the ascent differs somewhat in individual curves, not only of pulses of different frequency and character but also of the same tracing. In typical radial curves measured by Landois its mean duration was .097 second; in a number of radial curves written with my Marey's instrument, the period of ascent *a* B = .0903 second; in some curves by Pond's sphygmograph the average *a* B = 0.12 second. The variations in the duration of the ascent are not as great as of the descent, nor proportioned to them. A frequent pulse (of short duration) does not necessarily have a short period of dilatation—in other words it may be *tardus* as well as *celer*.—

It is evident that the form of the pulse-curve permits us to draw conclusions as to the conditions which contribute to determine it; these are, chiefly, the degree of tension of the arterial wall, the volume of blood added by each systole, and the force with which it is injected. Increased *tension* alters the form of the curve in the direction of the *p. tardus et durus* and diminishes its height; diminished tension produces a *p. celer et mollis* and increases the height of the curve, the area in each case remaining the same. Greater *volume* of blood likewise produces the form of the high-tension pulse, increasing at the same time the height and the area of the curve; lessened volume diminishes the area and makes the pulse quicker and lower. Increased *force* of systole (as in simple hypertrophy) causes a larger and quicker pulse; with simultaneous increase of volume of blood propelled the curve is still higher, or at least as high, but perhaps more tardy, and the area of the curve is greater. Diminished force alone makes the curve tardier and smaller; combined with diminished volume the curve becomes quicker and smaller, or at least not higher, and the area of the curve less. ——

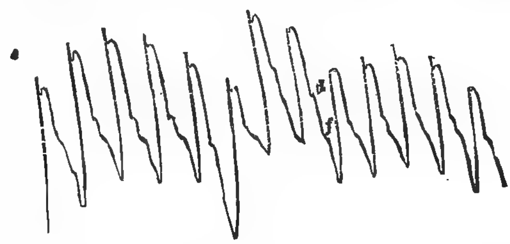

FIG. 3149.—Tracing of an Abdominal Pulsation. 116. (Marey's.)*

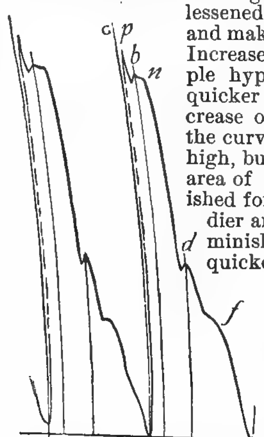

FIG. 3150.—Two Curves of Fig. 3149 Enlarged × 2 by Aid of Magic-lantern.

In Different Arteries the pulse registers different forms of curve. The tracings secured by Penzoldt[18] in a case of fissure of the sternum from the *ascending aorta*, revealed an anacrotic elevation—probably due to the movement of the auricles being communicated to the lever of the instrument—and near the apex an elevation evidently corresponding to the closing of the semilunar valves, but no other elevations in the down-stroke. I have lately obtained tracings from an abdominal pulsation, so well defined that they can fairly be taken as reproducing the pulse movements of the *abdominal aorta.**

The curve of the *carotid* pulse is characterized by considerable height, a steep up-stroke, an acute apex; on the down-stroke, close below the apex, is found the elevation attributed to the sudden closing of the aortic valves, commonly coinciding with the first elastic oscillation, and

* Mrs. M., fifty-seven years of age, washerwoman; greatly emaciated and worn by hard toil; irritable heart; pulse-rate, 116; pulsation above umbilicus so forcible and so distinct to inspection and palpation as to have suggested aneurism. It was equally accessible to the sphygmograph, as the figures show. They reveal a forcible percussion-stroke, *p* (see footnote on page 86); the true apex, *b*, is soon followed by the wave of the aortic valves, *n*, at almost the level of the apex, and the down-stroke is marked by both predicrotic, *d*, and dicrotic wave, *f*. The measurements agree very well with this interpretation. I have not met in literature with any other curves of the abdominal aorta. The tracing given by Ozanam (La Circulation et le Pouls, Paris, 1886) on page 694 is, of course, ludicrously inexpressive, as are, indeed, all the curves in that fearful and wonderful book.

constituting the predicrotic wave; the dicrotic wave is small, owing to the high tension in the carotid, and oc-

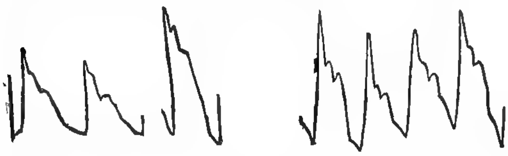

FIG. 3151.—Normal Carotid Curves; the first three after Eulenburg, the last four after Landois. (Marey's.)

curs early in the descent, owing to the nearness of the artery to the heart. The *subclavian*, and the more accessible *axillary*, arteries yield a similar tracing with a larger dicrotic wave. The pulse of the *brachial* artery in

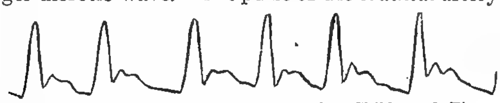

FIG. 3152.—From Right Brachial Artery of a Child aged Five. 90. (Pond's.)

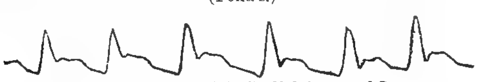

FIG. 3153.—From Right Radial Artery of Same.

the bend of the elbow differs from the radial pulse chiefly by its greater amplitude. In the curve taken from the *femoral* artery, the predicrotic wave is large and so high up as to delay the descent and blunt the apex, so that the curve looks much like a radial curve of high tension; but the dicrotic elevation is low down in the curve.

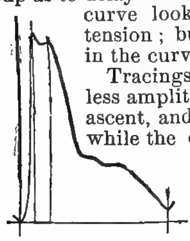

FIG. 3154.—From the Femoral Artery. (Marey's.) × 2.

Tracings from the *dorsalis pedis* artery have less amplitude than the radial, a more slanting ascent, and a distinct but late dicrotic wave, while the elastic oscillations are, as a rule, imperfect and weak; the pressure of the instrument easily prevents their expression in the trace, and we find the predicrotic wave only in very delicately written curves. Tracings can be taken from other accessible arteries, as posterior tibial, temporal, etc.; in a case of overactive heart, I have obtained one from the digital artery of the middle-finger.

In Different Individuals, the normal pulse differs widely in frequency, celerity, magnitude, and degree of tension. These personal variations are, however, remarkably persistent, so much so that the same person, under ordinary circumstances, always yields the same form of pulse-curve. Even when disease, as an acute fever, has altered the aspect of the tracing in all essentials, the curve after convalescence assumes again the qualities characteristic of the individual's pulse previous to the illness. Various physiological states modify the curve for the time being, in accordance with their well-known influence on the circulation. Thus, muscular labor, digestion, elevation of temperature make the pulse larger, softer, and more frequent. Cold, whether applied to the entire body or only to the part the artery of which is under examination, causes a smaller and harder pulse by vaso-constriction and rise of tension. Sex has no influence on the form of the pulse-tracing. Age, on the contrary, affects it in a conspicuous manner. *In the child*, the pulse-curve is marked only by distinctness of the elastic elevations, especially a well-developed and often high-placed predicrotic wave, while the dicrotic wave is but little prominent. The regularity of rhythm is more easily disturbed in the child than in the adult.

The *Pulse of the Aged* is very characteristic. The vascular changes of senile life do not set in at the same age in all persons, but sooner or later, almost certainly after the sixtieth year, they find expression in the pulse-curve. They consist essentially in a loss of elasticity of the arterial wall by gradual atheromatous changes. The rising blood-wave dilates the arterial tube but slowly, at least in the higher degrees of atheroma; once distended, the less elastic artery does not contract with the promptness required for the normal celerity of the pulse, but remains distended for a while; hence the apex is no longer sharp, but rounded or even flattened, all the more so because the predicrotic wave is large and near, or on a level with, the apex, owing to the high blood-pressure developed by the systolic filling of the rather unyielding vessel. Subsequent elastic elevations are absent. The dicrotic wave is present in moderate degrees of atheroma, but in most cases it is small, and in some almost obliterated. The pulse is eminently *tardus*. The pulse of the

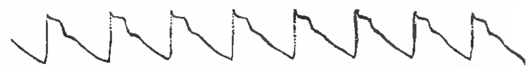

FIG. 3155.—Male, Seventy-nine Years of Age. 80. (Marey's.)

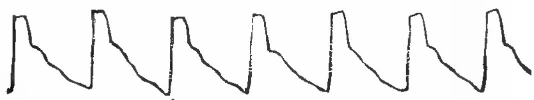

FIG. 3156.—Male, Sixty-two Years of Age. 66. (Marey's.)

FIG. 3157.—Male, Ninety-two Years of Age. 70. (Marey's.)

aged must not be confounded with a simply hard pulse; it retains its character of tardity—the labored ascent and rounded apex—even when the blood-pressure is diminished and the dicrotic elevation reappears with distinctness, as in fever. But when the heart is hypertrophied, the pulse of the rigid artery may have a steep ascent and an acute apex, while the down-stroke retains the characters described.

A sphygmographic tracing—sphygmogram—consists of a series of pulse-curves, which enable one to observe the rate of the pulse, its rhythm, and rapid fluctuations in the mean blood-pressure. The average pulse-rate is more readily, and quite as accurately, counted by the watch; slight variations in it are, however, best measured in the tracing. Rhythmical fluctuations of the blood-pressure and of the pulse-rate are caused in the normal tracing by the respiratory movements. All other changes in rhythm are pathological.

The Influence of the Respiration on the pulse is barely perceptible in a tracing taken during quiet, superficial breathing. As a rule, the basal points of all the curves of such a tracing are in a straight line parallel to the base line; but when the respiration is deep and slow,

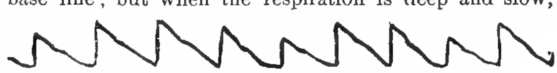

FIG. 3158.—Male, aged Thirty-two. 71. (Marey's.)

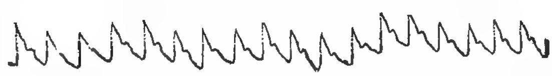

FIG. 3159.—Male, aged Thirty-eight. Chronic Parenchymatous Nephritis. Dyspnœa at the time. 116. (Marey's.)

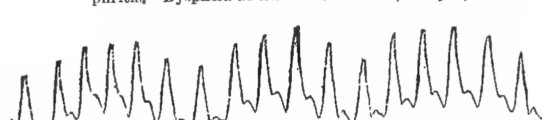

FIG. 3160.—Female, aged Thirty-two. Tachycardia. Subclavian artery. 140. (Pond's.)

the line connecting the basal points—the "respiratory line"—is often not straight, but undulating in unison with the respiratory movements. In such case, a line connecting the apices of the curves is still more undulating, because the pulses are largest on the summits

of the respiratory curves (as in Fig. 3160)—*i.e.*, the pulses coinciding with expiration are the largest; they also have a smaller and higher-placed dicrotic elevation; whereas those which coincide with inspiration are smaller, have a larger and lower-placed dicrotic wave, and a smaller predicrotic wave; they "begin to be dicrotic." Thus is expressed in the pulse-tracing the fact that the arterial blood-pressure rises during expiration and falls during inspiration. The inspiratory pulses are also somewhat more frequent then the expiratory pulses, the slowing beginning a little before the expiration and lasting a little beyond it (Penzoldt). This is particularly evident during voluntary slowing of the respiration. When, however, the breath is held in deep inspiration, the pulse-curve gradually increases in length (becomes less frequent), in height, and in area, and assumes the form of high tension.

The respiratory influence on the curves is plainly seen, as a rule, in the pulse of children, and is exaggerated during sleep—so much so that in many healthy children it is perceptible to palpation, and the pulse seems irregular, approaching in character the (pathological) *pulsus paradoxus* (see below). It is a clinical fact of some importance that this irregular pulse in a sleeping child is not a sign of disease.

The Pulse in Disease.—The more prominent alterations which the pulse suffers under morbid conditions may be classified as, (1) changes in tension, (2) changes peculiar to certain diseases of the heart and great vessels, (3) local changes in individual arteries or vascular territories, (4) changes of rhythm, and (5) changes of frequency.

1. In health, the average arterial tension differs widely in different individuals, and considerable differences in this respect are compatible not only with health, but with bodily vigor. But it will be noted that in case of either extreme the pulse is rather large; a small and soft pulse is frequently associated with low energy, a small and hard pulse is more often observed in persons of irritable habit and neurotic tendencies. Still, the individual variations are so large that in the absence of other signs they are of small prognostic value.

Moreover, in healthy persons, during rest and under seemingly unvarying conditions, the tension of the arteries is subject to frequent changes in degree, so that successive series of curves, taken with an instrument that remains in position for some time, show differences of form which must be ascribed to alterations of "tone" by vaso-motor influences, to which the play of mental activity and of emotions greatly contributes.[19] This mobility of the state of muscular contraction of the arteries is so constant in persons of vigorous health, that G. v. Liebig [20] considers its absence a sign of diagnostic value.

Among the influences which alter the tension more decidedly are cold and heat. A cold bath, a chilly room furnish opportunities for observing the increase in tension; a warm atmosphere, the elevation of temperature after a full meal or after vigorous exercise, at once alter the pulse-form in the opposite direction, even to dicrotism.

The alterations in the direction of lowered tension are seen in their higher degrees in

Dicrotism.—The dicrotic form of pulse results whenever the predicrotic elevation disappears, and the dicrotic wave is enlarged. Both changes occur when the blood-pressure falls sufficiently low, provided the elasticity of the arterial walls is intact. A dicrotic pulse is a pulse of low tension. Rigidity of the artery, as in atheroma, tends to prevent dicrotism. Sudden influx of blood, due to a short and energetic systole, assists in the development of the dicrotic curve, but is never alone competent to cause dicrotism, whose *conditio sine qua non* is lowered blood-pressure, especially when caused by relaxation of the vascular wall.* The conversion of a curve of fair tension into a dicrotic curve can often be seen in arhythmical tracings, as in Fig. 3194 (magnified in Fig. 3145).

The most conspicuous and best known example of the dicrotic pulse occurs in fever. Under the influence of greatly elevated temperature, the peripheric arteries relax, the arterial blood-pressure falls, and the pulse becomes exquisitely dicrotic, as has long been known in the case of typhoid fever, but is true of all febrile diseases. During the initial chill of an acute paroxysm, the pulse is small and hard; as the chill passes off it becomes large, full, and bounding (*magnus, plenus, celer*), even hard in the beginning of inflammatory fevers; but soon it becomes soft, easily compressed, and with increasing relaxation of the smaller arteries the radial pulse shows a dicrotism distinct enough to be appreciated by the finger. The influence of lessened tension in causing di-

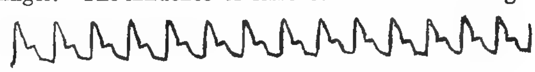

Fig. 3161.—Incipient Phthisis. Temperature, 99.4°; pulse, 114. (Marey's.)

Fig. 3162.—Catarrhal Fever. Temperature, 100.2°; pulse, 94. (Marey's.)

Fig. 3163.—Renal Dropsy; Low Tension. Temperature normal; pulse, 84. (Pond's.)

crotism is enhanced by a short and quick systole, and by the greater frequency of the pulse. A high pulse-rate, as such, does not cause dicrotism, but it assists in bringing about modifications in the curve that are characteristic of the degrees of dicrotism. When the normal curve passes into the dicrotic, the predicrotic wave disappears, the first part of the down-stroke is steep and long; the dicrotic wave, while it grows in height, is delayed; the diastolic notch approaches the base line, as in Figs. 3161 to 3163; the pulse is *sub-dicrotic*. With still lessening tension, the great notch reaches the base line, as in Figs.

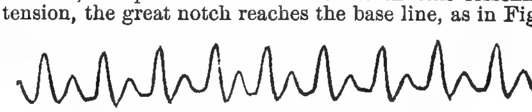

Fig. 3164.—Typhoid Fever, Third Week. (Pond's.)

Fig. 3165.—Phthisis Pulmonalis. Temperature, 102.3°; pulse, 114. (Pond's.)

3164, 3165, which exhibit *full dicrotism*, or even falls below the base line, as in Figs. 3166, 3167, the *hyperdicrotic* pulse. In the first instance, the lever in the second por-

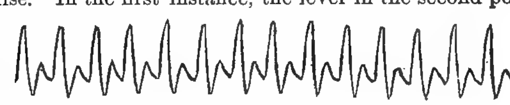

Fig. 3166.—Continued Fever. Temperature, 103.2°; pulse, 124. (Pond's.)

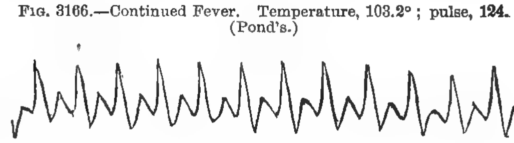

Fig. 3167.—Typhoid Fever. Temperature, 103.4°: pulse, 124. (Pond's.)

tion of the descent falls lower than in the first portion; in the fully dicrotic pulse, partly owing to greater fre-

* For it is by no means certain that the ready and invariable conversion of a normal pulse into the dicrotic form in fever is due solely to diminished blood-pressure; the altered innervation, or a direct influence of the febrile temperature upon the muscular coat, is probably a positive factor in this process, as well as an (indirect) means of reducing the blood-pressure. Changes in the degree of dicrotism do not always run parallel with changes in blood-pressure; dicrotism sometimes disappears without a corresponding rise of pressure.

quency of the heart's action, the following systole raises the lever when it has reached a point as low as the diastolic notch; in the hyperdicrotic pulse, the lever is raised by a still earlier systole before it has reached that point; the great notch lies below the line connecting the basal points. If the frequency of the pulse becomes still greater, the succeeding systole lifts the lever when it has reached the summit of the dicrotic wave; the lever has not time to make a second descent, and the pulse has made only one elevation, one beat—is *monocrotic*, as in Fig. 3168. Thus the degree of dicrotism depends partly

FIG. 3168.—Typhoid Fever. Temperature, 104.8°; pulse, 160. (Marey's.)

on the delay of the enlarged dicrotic wave and the deepening of the great notch, and partly on the frequency of the pulse. When, however, the usual parallelism between the temperature, the relaxation of the peripheric vessels, and the beat of the heart is disturbed (as by medication), it may happen that even very great frequency

FIG. 3169.—Typhoid Fever. Under Antipyrin. Temperature, 100.8°; pulse, 140. (Pond's.)

does not produce a monocrotic pulse (see Fig. 3169). On the other hand, monocrotism can occur only in a very frequent pulse.

The degree of dicrotism corresponds in a measure to the degree of fever; the higher the temperature, the lower the tension; as the fever rises, the pulse-curve gradually passes through the successive changes of form described. With a temperature of 39° to 40° C. (102° to 104° F.), we may confidently expect, in acute fevers of previously healthy adults, a fully dicrotic pulse; beyond it the curve becomes hyperdicrotic or even monocrotic. This parallelism is, however, not at all constant, but subject to many influences, one of which is the frequency of the pulse, another the strength of the patient. In feeble persons, in chronic febrile diseases, in the later stages of acute fevers, even, the various phases of dicrotism are reached with lower temperatures; thus, at 39° C. (102° F.), a phthisical patient may yield a hyperdicrotic curve, while a pneumonic or typhoid patient may, at the same temperature, have a sub-dicrotic pulse. In individuals who previously had a high-tension pulse, *i.e.*, whose usual pulse-curve was farther removed from the dicrotic pulse than is the normal, fever develops the phases of the dicrotic pulse only with higher temperatures.

As the fever abates, the pulse-form gradually returns to the normal, but not quite as rapidly as the temperature sinks; and sometimes the pulse remains subdicrotic during convalescence, or shows the form of normal tension only with subnormal temperatures.

By the finger, dicrotism is recognized most easily when the difference in height between the two waves is least, and the pulse is neither very frequent nor very small—in the fully dicrotic pulse of undulating character. The dicrotic beat is also perceived with distinctness in a subdicrotic pulse of moderate frequency. In the hyper-

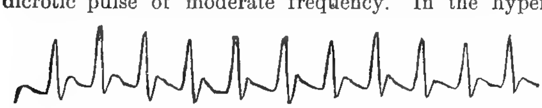

FIG. 3170.—Pulmonary Hæmorrhage. Temperature normal; pulse, 100. (Pond's.)

dicrotic pulse the second beat is felt as a grace-note to the succeeding primary beat, *p. caprizans*.

While fever furnishes the most pregnant examples of low tension pulse, all other causes of low blood-pressure have more or less dicrotic forms of pulse. High degrees of anæmia, collapse, sudden losses of blood, fatty heart, and other conditions of cardiac debility, alter the curve in the same direction. Drugs which reduce the blood-pressure rapidly are capable of causing dicrotism, notably amyl-nitrite.

The Pulse of High Tension is caused mainly by obstructed outflow toward or through the capillaries, as by contraction of the arterioles. It is marked by high position and large size of the predicrotic wave, and by small size of the dicrotic wave. It can be produced

FIG. 3171. Digitalis. 52. (Marey's.)

artificially by drugs which raise the blood-pressure, by none more readily than digitalis (Fig. 3171).

Among diseases, lead-poisoning, gout, and Bright's disease, especially the first stage of acute nephritis and contracted kidney, furnish the most common examples of high-tension pulse. In acute nephritis, the pulse is often hard from the beginning and before hypertrophy of the heart has been developed, and retains this character for some time. In chronic parenchymatous nephritis we commonly miss this symptom (compare Fig. 3159). But in contracted kidney, especially the genuine arterio-sclerotic form, the high-tension pulse (*durus*, *tardus*, and often *magnus*) is an early, sometimes the earliest, sign, and apt to persist until near the fatal end,

FIG. 3172.—Female, aged Twenty-two. **Contracted Kidney; Retinitis.** 74. (Pond's.)

FIG. 3173.—Male, aged Sixty. Contracted Kidney. 56. (Marey's.)

enhanced or modified by hypertrophy of the left ventricle (Figs. 3172 and 3173).

Hypertrophy of the heart, alone, does not produce the high-tension pulse; *i.e.*, the blood-pressure is not necessarily high between the beats. The energetic contraction of a large ventricle, especially when the pulse is not frequent, causes a large pulse; but if other causes of high tension are absent, if the outflow through the capillaries is free, the pulse does not show the tardity of the common *p. durus et tardus;* the up-stroke is very steep,

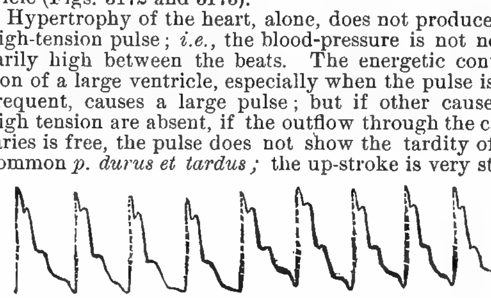

FIG. 3174.—Male, aged Forty-eight. Hypertrophy of Heart. 62. (Marey's.)

and although the predicrotic wave may be large and near the apex, the fall of the lever immediately afterward is sudden, the dicrotic wave apt to be low down and fairly developed. Thus the pulse of hypertrophy can usually be distinguished from the *p. tardus* of Bright's disease and of atheroma.

Pregnancy has been found to induce a high-tension pulse; and in some anæmic patients, the arterial tension is unexpectedly high. A certain class, too, of nervous women of spare habit, suffering from paroxysmal painful affections, vague and shifting neuralgic pains or more pronounced neuralgias, megrim and other headaches, present a uniformly tense but small pulse. This is certainly not the pulse of high tension which precedes arterio-sclerotic kidney disease, but is owing to irritation or abnormal irritability of the vaso-constrictor nerves. It has proved valuable to me in arriving at indications for treatment.

2. *Valvular Disease of the Heart*, modifying the pulse-

movement at its source, impresses its characters on the curve, though not so specifically as to enable one to diagnosticate valvular lesions from the pulse-curves, even with the aid of cardiograms; the sphygmograph only furnishes evidence of the same kind, and of the same value, as that which is obtained by auscultation and percussion of the heart. *Mitral regurgitation*, so long as it is perfectly compensated by the strength of the heart, simply lowers the blood-pressure (the ventricle not discharging all it contains into the aorta), and yet frequently

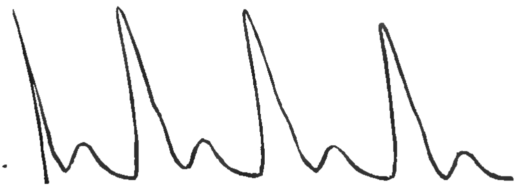

FIG. 3175.—Mitral Insufficiency, Compensated. 90 to 100. (Burdon-Sanderson's.)

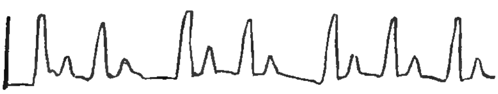

FIG. 3176.—Mitral Insufficiency, not Compensated. 75. (Pond's.)

increases the height of the curve (by an energetic systole); hence makes a soft and often large pulse. When compensation is (temporarily or permanently) disturbed, the pulse becomes frequent and irregular in rhythm, as will be described below. In *mitral stenosis* the pulse is small, soft, and sometimes frequent; when the heart's muscular power becomes impaired, it grows more or

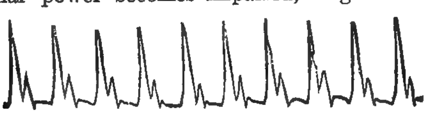

FIG. 3177.—Aortic Regurgitation. 98. (Pond's.)

less irregular. Irregularity of pulse is a mark of mitral affections, rather than of aortic lesions. *Aortic regurgitation* gives, of all valvular defects, the most characteristic curve. If perfectly compensated, it can be so only by hypertrophy of the ventricle, and this tells its tale in the curve; but if the incompetency of the valves is considerable and compensation incomplete, signs of the regurgitation are visible in the sphygmogram. The hy-

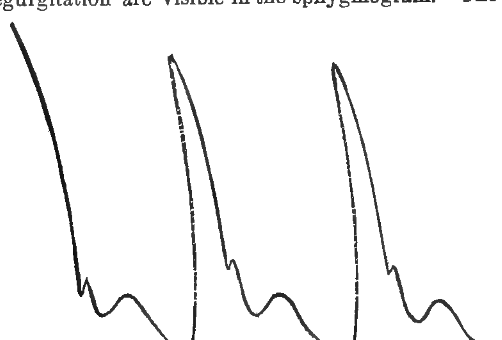

FIG. 3178.—Aortic Regurgitation with Mitral Insufficiency, the Former Predominating. 80. (Burdon-Sanderson's.)

pertrophy causes a high and very steep up-stroke; the curve is always large and the descent is rapid at first, because during the diastole blood flows back into the ventricle as well as onward to the capillaries; the predicrotic wave is usually low down and of varying size, often small; the dicrotic wave is small and well down toward the base line. The artery, then, is quickly and forcibly distended, and as quickly contracts again. A pulse of this character is easily recognized by palpation; it is eminently *celer*, quick to come and go, and yet large and strong, giving the impression of the rebound of a

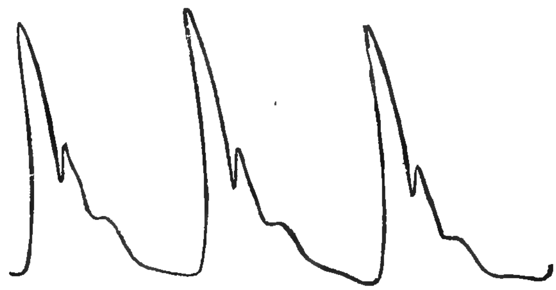

FIG. 3179.—Aortic Regurgitation. 76. (Burdon-Sanderson's.)

hammer, or of a bullet passing under the finger; the "shotty" or "bullet" pulse. It is usually quite regular. The normal delay of the pulse as compared with the heart's impulse is abnormally shortened; Keyt[21] deems this symptom so characteristic, that in the absence of fever it is pathognomonic of aortic insufficiency of high

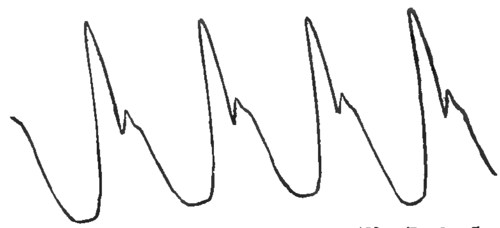

FIG. 3180.—Aortic Regurgitation, Traumatic. 120. (Burdon-Sanderson's.)

degree. Sometimes the up-stroke is interrupted by an elevation, which Landois interprets as an expression of the auricular systole that makes itself felt through the partially open aortic orifice.

The pulse of *aortic stenosis* is commonly regular, often small, and always very tardy, as its mode of formation

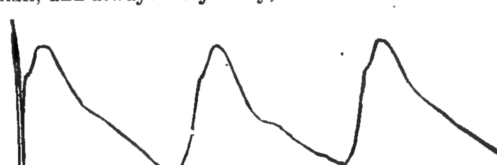

FIG. 3181.

FIG. 3182.

FIGS. 3181 AND 3182.—Aortic Stenosis. 80. (Burdon-Sanderson's.)

FIG. 3183.—Aortic Stenosis. 78. (Pond's.)

explains; the probably hypertrophied ventricle presses a limited volume of blood into the artery with difficulty, hence slowly; therefore the up-stroke is slanting, and the entire systolic portion of the tracing is prolonged; the "apex" is lower than the summit of the curve, and constitutes an ("anacrotic") elevation in the ascent. The smallness of the pulse often contrasts strongly with a forcible impulse of the heart.

Valvular defects of the right heart can have only an indirect effect on the arterial pulse-curve. Combinations of two or more valvular lesions do not yield curves as transparent in their meaning as those of pure cases; yet

even here, comparison of the pulse records with the cardiograms and the results of physical exploration is a material help in diagnosis.

Disease of the Arteries manifests itself chiefly in the hard pulse of arterio-sclerosis (as in chronic Bright's disease), and in the tardy pulse of atheroma. The influence on the pulse of atheromatous disease has been noticed in describing the pulse of the aged, the chief characteristic of which is its tardity. In high degrees

FIG. 3184.—Atheroma. 45. (Burdon-Sanderson's.)

of atheroma we witness the appearance of an anacrotic elevation (Fig. 3184).

Anacrotic Elevations—secondary waves in the line of ascent (Figs. 3181 to 3184)—are found only in disease; they require for their formation a lengthened and labored influx of blood, either by reason of great volume of blood pressed in, as in dilatation of the left ventricle, or because of an unyielding artery, as in Bright's disease, in atheroma, etc. Often both conditions concur. The anacrotic pulse is always a *p. tardus*. The occasional appearance of anacrotism in the pulse of paralyzed parts (when the vaso-motor nerves are included in the paralysis), Landois explains by the loss of active contractile power ("tone"), slowing of the circulation, venous and capillary stasis, and hence increased impediments to the influx of blood into the arteries. The anacrotic wave which sometimes (rarely) arises in the pulse of aortic regurgitation has an entirely different origin in the transmission of the wave of the auricular systole through the open aortic orifice.

3. *Local Differences in the Pulse.*—At times the pulse of one artery is found to differ from that of the corresponding vessel of the other side—*p. differens*. Apart from anatomical anomalies, the differing pulse is caused either by (more or less local) changes in innervation or by mechanical means. Among the former class of causes—which are very numerous—is cold applied to the part; an arm exposed to cold yields a radial pulse of higher tension and less height than its warm fellow. A dicrotic pulse confined to one artery or limb indicates paralysis of its vaso-motor nerves. In hemiplegia the paralyzed side commonly gives a softer pulse, with a more rounded apex,

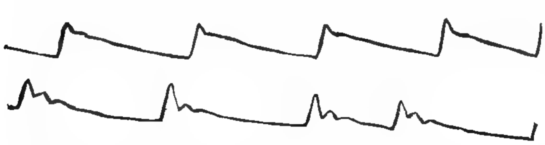

FIG. 3185.—Hemiplegia (cerebral), Recent. Upper trace from left radial, normal; lower trace from right radial, paralyzed. 54. (Pond's.)

a high predicrotic and a feeble dicrotic wave; sometimes, indeed, the otherwise rare combination of *p. mollis et tardus*. Sometimes the tardity is more pronounced, even to anacrotism; the primary wave does not reach high enough to form the apex.

Among the mechanical causes of the differing pulse are compression of the artery, as by tumors, cicatrices, adhesions, etc.; obstruction of the venous current by similar means; and aneurisms situated between the heart and the vessel examined, which do not interfere with the circulation of the other side.

Smallness of the left radial pulse, as compared with the right, has been observed by Traube[22] in cases of pericardial exudation. The phenomenon is explained by pressure of the enlarged pericardial sac on the arch of the aorta. A greatly dilated heart has been found to produce the same effect, probably in the same manner.[23]

4. *Altered Rhythm; Allorhythmia cordis; Arhythmia cordis; Intermittent Pulse.*—While the normal tracing, aside from the slight modifications of rhythm produced by normal breathing, shows pulses of almost equal duration and magnitude, many deviations are met with in disease. A frequent occurrence is the feebleness or entire suspension of a ventricular contraction, resulting in the dropping of one beat of the pulse, now and again, sometimes at regular intervals, sometimes irregularly—

FIG. 3186.—Intermittent Pulse. 84. (Pond's.)

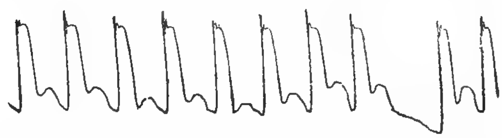

FIG. 3187.—Intermittent Pulse. Kidney disease consequent upon enlargement of the prostate and cystitis, in a patient aged eighty-three; fever. Temperature, 101.6°; pulse, 92. (Marey's.)

the *intermittent pulse*. True intermittence, due to actual absence of systole—*p. deficiens*—can be recognized by absence of cardiac impulse and of both sounds. The systole may take place, however, yet not be strong enough to open the aortic valves against the blood-pressure in the aorta, and hence cause no wave in the arterial system—*p. intermittens*; or it may have force to cause a small wave, registered by the sphygmograph, but not percepti-

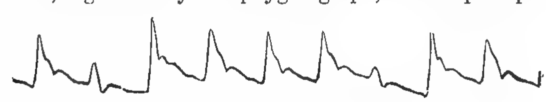

FIG. 3188.—Pulsus intercurrens. 77. (Pond's.)

ble to the finger, or only felt as a very feeble beat—*p. intercurrens* or *intercidens*.

In some cases feeble systoles occur with great regularity; *e.g.*, they alternate with strong contractions, causing an alternation of strong and feeble pulses—*p. alter-*

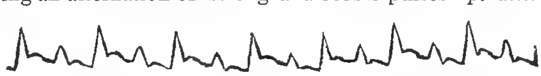

FIG. 3189.—Pulsus alternans. Apoplexy. 110. (Pond's.)

FIG. 3190.—Pulsus alternans. Chronic Nephritis. 140. (B. Sanderson's.)

nans. The feeble pulses may be so small as not to be easily perceived by the finger, so that a pulse-rate of 80 is counted as 40. Or the feeble systole may take place soon after a cardiac contraction of ordinary force; the result is that the pulses appear in pairs, in which the first has a high ascent and a short descent, the second a short ascent and a long down-stroke—*p. bigeminus*. Sim-

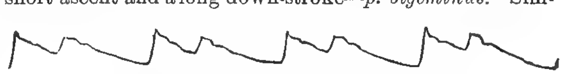

FIG. 3191.—Pulsus Bigeminus. (Pond's.)

ilarly, one strong systole may be followed by two feeble ones in quick succession, making a *p. trigeminus*, etc. In certain cases the second contraction, which cuts into the diastole of the first, working with an almost empty ventricle, has not strength to open the aortic valves, and therefore fails to cause a pulse—an alternately intermittent pulse, as it were; one pulse to two systoles, or, rather, a bigeminous action of the heart in which the futile second twin contraction makes no pulse.

In the case from which Figs. 3192 and 3193 were taken, three sounds of the heart were heard to each pulse at the wrist, the third sound being the systolic sound of the fu-

tile systole, which was not followed by a diastolic sound. This condition has been described and much discussed[24]

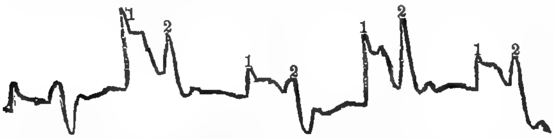

Fig. 3192.—Cardiogram of Bigeminous Action of Heart. 1, 2, Indicate the first and second systole of each twin pair; the lower phases correspond to inspiration, the higher to expiration. Contractions of heart, 80. (Marey's sphygmograph.)

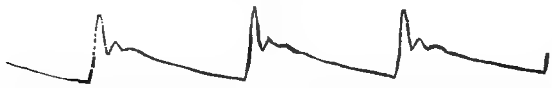

Fig. 3193.—Sphygmogram of Radial Pulse of Same Individual. Pulse-rate, 40. (Pond's.)

under the name of intermittent hemisystoly of the heart,* and of *Herzbigeminie.*

In some cases the pulses vary in regularly graded groups, as in Fig. 3194, where an ordinary pulse of fair

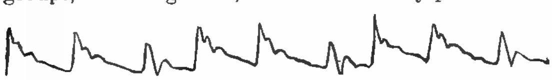

Fig. 3194.—Male, aged Twenty-eight. Abuse of Tobacco. 77. (Pond's.)

tension is followed by a smaller and softer one, and that again by a still smaller, still softer, dicrotic pulse—such groups of three recurring again and again.

All the foregoing varieties of rhythm have been spoken of as *allorhythmia cordis*—altered rhythm, in which the inequalities of size as well as of sequence follow certain rules or types—in distinction to the quite irregular action of the heart that wipes out all rule and rhythm—*arhythmia*, *ataxia*, or *delirium cordis*, of which Figs. 3195 to 3198 furnish examples. In Fig. 3198, from a

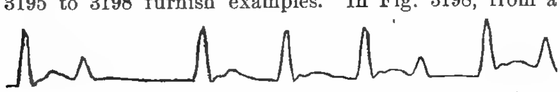

Fig. 3195.—Mitral Disease; Dilatation of Left Ventricle, some Aortic Regurgitation; Compensation Disturbed. (Pond's)

Fig. 3196.—Male, aged forty-nine. Præcŏrdial Oppression; "heart gets tangled" occasionally. No physical signs. (Marey's.)

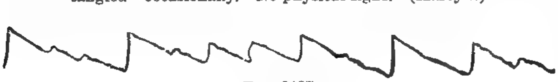

Fig. 3197.

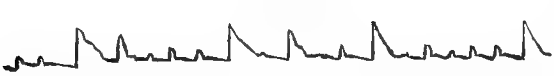

Fig. 3198.

Figs. 3197 and 3198.—Male, aged Sixty-five. Atheroma; Disease of Coronary Arteries; Angina Pectoris. (Marey's.)

patient with atheroma, including the coronary arteries, with myocardial changes, who suffered most violent attacks of stenocardia, one full beat is succeeded by a variable number of feeble ones, and the very frequent pulse is at times utterly irregular.

All these phenomena of arhythmia and allorhythmia are of similar origin; their fundamental cause is disturbed innervation, arising either within the heart (from lesions of structure or of circulation in the heart's muscle) or in the vagus or sympathetic, or coming through these nerves from the cerebral centres—either directly, as in cerebral disease, disease of the pneumogastric nerve (compression by tumors, scrofulous glands, etc.), and in psychical disturbances; or reflexly (as in lesions of digestion, disease of the liver); or as a result of intoxication (by tobacco, tea, or coffee). These causes operate more readily upon the already enfeebled or overtaxed heart; hence we meet with them in anæmic persons, in convalescents from acute diseases, in valvular lesions which have passed the stage of compensation. Complete arhythmia is seen most frequently in chronic diffuse myocarditis,[25] of which it is almost characteristic when persistent and not merely paroxysmal. In uncomplicated disease of the mitral orifice it occurs more frequently in paroxysms and varies much in degree; digitalis tends to diminish the irregularity, while in chronic myocarditis the same remedy has no influence over it.

A disturbed rhythm of an altogether different kind is the *pulsus paradoxus* of Kussmaul.[26] It consists in a diminution or total suppression of the pulses which coincide with inspiration. Two distinct groups of cases, of entirely different origin, show this phenomenon. One group is owing to obstruction to the free ingress of air into the lungs, augmenting the inspiratory effort and thus intensifying the inspiratory lowering of pressure within the thorax—to such an extent that the proper filling of the left ventricle is prevented, and the latter, during inspiration, throws into the aorta an amount of blood too small to cause a pulse-wave in the radial artery. This symptom has been observed in stenosis of the air-passages (croup, paralysis of the crico-arytenoid muscles, compression of the trachea by tumors), as well as in a case of capillary bronchitis (Bäumler[27]). In this group the phenomenon is simply an exaggeration of the (normal) influence of the respiratory movements.

In the second group of cases, the paradoxical pulse results from mechanical compression of the aorta by means which are brought into action only during inspiration. This was first observed (by Kussmaul) in cases of mediastinal adhesions of the pericardium, the fibrous bands being put upon the stretch whenever the sternum makes its forward movement in inspiration, and, by constricting the aorta, obstructing the flow of blood through it. In such case the same compression is exerted upon the venæ cavæ, and manifests itself in a swelling of the jugular veins with each inspiration. The combination of the latter symptom with the *p. paradoxus* is pathognomonic of fibrous mediastino-pericarditis. The paradoxical pulse alone is not so characteristic, for it has been found (Bäumler, Hindenlang[28]) in cases of hydropericardium without fibrous adhesions; here, however, the veins of the neck were permanently distended, not more during inspiration than during expiration.

5. *Morbid Changes in the Pulse-rate.*—The physiological conditions which modify the frequency of the pulse, when exaggerated in disease, will naturally change the rate in the same direction. Increased muscular activity, as in tetanus, increased chemical change in muscle or in the tissues generally, as in fever (elevation of temperature, etc.), raise the pulse-rate; *vice versa*, lessened muscular activity and the lessened production of heat in convalescents from acute diseases lower the pulse-rate. An apparent exception is observed in convalescence from typhoid fever, when the frequency of pulse remains high even in the absence of all morbid symptoms (Traube). In general, it may be borne in mind that in disease, as in health, low blood-pressure commonly goes with frequent pulse. The limits of this article forbid entering upon details; only those cases can be alluded to in which morbid frequency or rarity of the pulse is the prominent, the most telling, symptom.

In many instances persistently rapid action of the heart may be ascribed to weakness of the heart (with dilatation ?), as in the so-called "irritable heart," due to either prolonged over-exertion or to sudden strain, as in lifting, running, rowing. In other cases it is clearly, or

* The name *Hemisystolie* was applied on the hypothesis that a normal systole of both ventricles was followed by a systole of the right ventricle alone. Sufficient evidence has not been brought to the support of this assumption. On the other hand, the occurrence of feeble systoles of the entire heart—so feeble that the left ventricle is not competent to open the aortic valves—is well known. Fick demonstrated such incomplete systoles as occurring in the morphine-narcosis of rabbits (Verhandlungen des V. Congr. f. innere Med., p. 97, 1886; and Riegel, *ibid.*, p. 101). Compare, also, Marey, Bull de l'acad. de méd, No. 42, 1883; Centralblatt f. klin. Med., No. 11, p. 181, 1884.

by exclusion, attributable to lesions of the cardiac nervous apparatus; the great frequency of the pulse in exophthalmic goitre is evidently of this character.

The name *tachycardia* (ταχύς, quick) has been applied to a class of cases in which an habitual high pulse-rate continues for a long period (in the absence of fever), interrupted or not by shorter paroxysms of an enormously accelerated action of the heart—a condition to which anæmic persons seem more predisposed than others. It occurs in the course of organic disease of the heart, or more often independently of it. In many instances it can be traced distinctly to lesions of the nervous system; among the anatomical lesions, those of the pneumogastric nerve, either central (in the medulla oblongata) or peripheral (compression by tumors or by cicatricial tissue*), offer the readiest physiological explanation. The affection may be accompanied by normal or by lowered tension; in the latter event the paralysis or paresis of the pneumogastric, or of the cardio-inhibitory centre, is associated with temporary paresis of the vaso-motor centre or fibres.[30] Tachycardia by irritation of the accelerating fibres in the sympathetic is less frequent, rarely of high degree, and more often paroxysmal than habitual. Theilhaber[31] reported a case caused by retroversion of the uterus—pulse, 200, temperature, normal; after reposition and retention of the womb by pessary, pulse, 80–90; after removal of the pessary, pulse, 110. Finally, tachycardia is caused by toxic agencies—coffee, tea, tobacco—and by gout. The paroxysms of extreme frequency may be excited by indigestion, flatulence, or any causes which ordinarily excite the heart's action.

In either form, the paroxysmal or the persistent, tachycardia may be accompanied by distressing symptoms, as palpitation, præcordial pain and anxiety, dyspnœa, feeling of "goneness," syncope, cold sweats; but even the palpitation is not always felt, and the amount of suffering is not always proportionate to the frequency of the pulse, sometimes, indeed, insignificant. The rate of pulsation may rise in the paroxysms to over 200, even over 300, as in the case of Bristowe, quoted by Broadbent.[32] Between the paroxysms, and in the habitual form, a rate as high as 164 has been observed. Of the two vagi, lesion of the left nerve seems to give rise to the greater acceleration. The tachycardia depending on structural lesion of the nervous apparatus is apt to be constant and of indefinite duration; the "neurotic" and toxic forms are more often paroxysmal. The paroxysms last from a few hours to several days; Dölger[33] relates a case in which the severe attack lasted seven days, Broadbent one in which for about three weeks "the pulse was never under 200, usually 240."

Less often do we meet with slow action of the heart as a consequence of morbid conditions. In its minor degrees the rare pulse is induced by morbid rise of blood-pressure; it is also caused by certain poisons, among them the bile-acids, whence the low pulse-rate sometimes found in jaundice. The rare pulse observed in some cerebral affections (*e.g.*, tubercular meningitis) may be due to anæmia or venous hyperæmia (more especially of the medulla oblongata) or to compression of the brain. Sudden slowing of a previously frequent pulse often announces a serious cerebral complication. In glosso-labial paralysis the pulse-rate has been found greatly diminished, probably from central excitation of the cardio-inhibitory fibres.

The higher grades of rare pulse—*p. rarissimus, bradycardia* (βραδύς, slow)—are usually connected with certain affections of the heart itself. Nauwerck[34] reported a case of inflammation of the parietal endocardium in a person sixty years old, with the pulse sometimes falling to 20 per minute. More often the highest degrees of bradycardia are connected with fatty heart, arteriosclerosis, and especially sclerosis and calcification of the coronary arteries, by means of their deleterious effect on the nutrition of the myocardium (?). Such cases abound in literature.[35] The pulse is usually anacrotic and very tardy.

FIG. 3199.—Female, aged Seventy-seven. Extensive Sclerosis of Coronary Arteries; Fatty Degeneration of Heart. Pulse-rate, 13 to 14. (Marey's.*)

It has been suggested that many of these cases are really heart-bigeminism, because sometimes the rate drops suddenly from, say, 60 to 30, and on improvement the bigeminous pulse appears as a transition to the normal rhythm and rate. But this is not the rule.

The connection between the structural disease of the heart and the lesion of innervation is not clear. Kisch[36] suggests, for the fatty heart of obese persons, that the lipæmia often found to exist in universal lipomatosis exerts the toxic effect of slowing the heart's action which has been obtained experimentally, in animals, by increasing the fats in the blood.

Concomitant symptoms, when present, are chiefly dyspnœa and præcordial anxiety, Cheyne-Stokes respiration, vertigo, syncope, and epileptiform seizures.[37] The epilepsy, in such cases, seems due to anæmia of the brain, closely related to the attacks of syncope which threaten the patient, especially when he assumes the upright position. Tripier,[38] on the contrary, thinks that epilepsy is the cause of the slow pulse; that hemisystoly, or heart-bigeminism, is always due to epilepsy, which is certainly too sweeping a conclusion;[39] the reverse relation seems to be the usual one.

THE CARDIOGRAM.—A graphic record of the impulse of the heart against the chest-wall can be obtained by means of sphygmographs constructed on the principle of Marey's; or by modifications of the same for their better application to the thorax, as Galabin's cardiograph; by transmission instruments, after the pattern of the cardiographs of Marey, Burdon-Sanderson, Meurisse et Mathieu, the compound sphygmograph of Keyt, and the pansphygmograph of Brondgeest. Less perfect tracings are made with Pond's and Dudgeon's sphygmographs.

The tracings of the apex-beat registered by these instruments are not as transparent in meaning as the sphygmogram, because they represent a greater complexity of movements, subject to more varying conditions, altered by the thickness and varying tension of the soft parts overlying the heart in the intercostal space, and apt

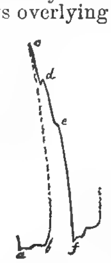

FIG. 3200.

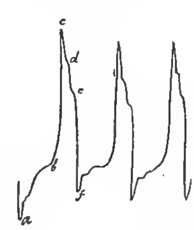

FIG. 3201.

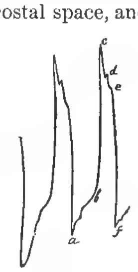

FIG. 3202.

FIG. 3200.—Normal Cardiogram. Pulse-rate, 81. (Sphygmograph of Marey (Breguet).)
FIGS. 3201, 3202.—Normal Cardiograms, after Landois. Pulse-rate, 74.2; respiration, 113.1. (Marey's sphygmograph.)

to be seriously confused by the simultaneous respiratory movements of the chest. Hence it may happen that only one or a few curves of a series give a complete and pure record of the heart's impulse. The latter is a rhyth-

* A case in point was observed by the writer, in which the right pneumogastric and sympathetic were both involved in a deep cicatrix in the neck, remaining after a very large and deep-seated abscess. The pulse-rate ranged from 110 to 140 and over for several months; pulse of low tension; general venous stasis (cyanosis), especially of the extremities and of the mucous membrane of the throat (from paresis of vaso-motor fibres in the cervical sympathetic?), more pronounced on the right side.

* This curve was taken several days before the death of a woman of seventy-seven years, who at the time suffered from great debility and had some spasms, chiefly of the muscles of the face and neck. The respiration was accelerated—26 and over. The pulse-rate on the previous day had been 10 per minute. Autopsy revealed a high degree of fatty degeneration of the heart and extensive atheroma of both coronary arteries, the left being very rigid and contracted, for nearly an inch almost impervious.

mical elevation and recession over the site of the apex, expressing the sum of the movements communicated to the chest-wall by the changing position, form, and consistency of that portion of the heart, and due to the contractions of the four chambers of the heart and to the closure of their valves. The normal cardiogram is the expression, therefore, of a considerable number of conditions, subject to great variations in themselves and disturbed by the acts of respiration. Nevertheless the apex-tracing of healthy persons is a characteristic curve, the details of which can be recognized in cardiograms of seemingly great disparity, and lend themselves in their main features to a comparatively simple interpretation.

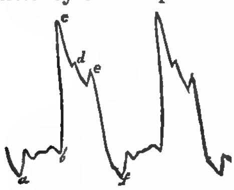

FIG. 3203.—Normal Cardiogram, after Galabin. Pulse-rate, 70. (Galabin's cardiograph.) (The lettering is altered to conform to that used in the present article.)

The lowest point in the normal cardiogram, a, marks the time when the ventricles have fully relaxed, and hence lies in the diastolic portion of the curve. From this point on (toward the right) we note a rise in the curve, more or less sudden, expressive of the filling of the ventricles, with one or more minor elevations produced by the contraction of the auricles. At the point b begins an abrupt and higher rise of the lever in obedience to the sudden contraction of the ventricles, and the termination of this rise forms the highest point, or apex, of the normal curve, c. The ventricles remain in systole for some time longer, during which the lever gradually falls to the point e. This portion of the curve is marked by two small elevations, d and e, which correspond to the closure of the aortic and pulmonary valves respectively.* The sudden relaxation of the ventricles now causes an abrupt fall of the lever from the point e to the lowest point of the curve, f (= a of the following curve). The palpable impulse of the heart coincides in time with the portion of the curve lying between b and e; the first sound of the heart is heard to begin at b; the second sound coincides with d and e. Landois has demonstrated that the aortic and pulmonary valves do not close exactly at the same time; but the interval between the two sounds produced is too short (.05 to .09 sec.) to be perceived by the ear, so that they are heard as one, while the elevations they start in the tracing are separate. It is only when the interval considerably exceeds the normal that the closure of the two sets of valves is revealed to the ear in separate sounds—*i.e.*, the second sound of the heart is "reduplicated."† The cause of the interval is the difference in blood-pressure in the aortic and pulmonary systems; that in the aorta, being much greater, leads to an earlier recoil, even though both ventricles complete their systole and relax at the same time.

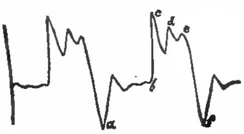

FIG. 3204.—Normal Cardiogram, after Keyt. Pulse-rate, 72. (Keyts' compound sphygmograph.) (Lettering altered.)

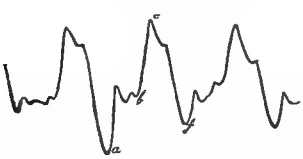

FIG. 3205.—Normal Cardiogram. Pulse-rate. 66. (Dudgeon's sphygmograph.)

The line $b\ e$ may be called the systolic portion of the curve; the line from e to the point b of the next curve, $e\ f + a\ b$, the diastolic portion, consisting of the pause and the auricular systole. The period $b\ e$ (between the first and second sounds) commonly measures about two-fifths of the entire cardiac revolution. Keyt found, as an average of twenty measurements, with a mean frequency of 74.7, or a pulse-length of .8075 sec., the systole = .3269 sec., the diastole = .4806 sec. With less frequent beats the diastole becomes longer, with greater frequency shorter, while the systole may vary in either direction.*

In the cardiogram taken while respiration is performed, the individual curves of the series are of very different height, and their details are not nearly so uniform as those of the sphygmographic tracing, owing to the disturbing influence of the respiratory movements of the chest-wall. At the height of an inspiration, owing to the interposition of the borders of the lung, the apex-beat becomes less visible and less distinct to palpation than during expiration, and deep respiration increases these differences; in shallow respiration they may escape detection by the hand or finger, but they are still perceptible in the cardiogram. (Compare Figs. 3208, 3209.) This (normal) behavior of the tracing presupposes that the anterior border of the left lung is intact and making its normal excursions. Adhesive inflammation, which fixes the left lung so that its border does not cover the cardiac apex during inspiration, is apt to reverse the differences in the curves in such wise that the higher phases of the cardiogram correspond to inspiration, the low curves to expiration, because during inspiration the intra-ventricular pressure rises.[43]

Pathological.—In cases of heart disease the tracings of the cardiograph may contribute to our appreciation of the details of the heart's action, and hence to diagnosis. Much has yet to be learned in this direction. In individual cases our knowledge may be further enhanced by tracings taken at other points than the site of the apex—*e.g.*, in or toward the second left intercostal space to demonstrate increased tension in the pulmonary artery (accentuation of the pulmonary second sound), or over areas in which a systolic retraction of the chest-wall is visible, where the tracing will be in a sense "negative:" the systolic ascent will be converted into a descent, and *vice versâ*, while the secondary (valvular) elevations will remain positive.

Pathological apex-curves exhibit enormous differences in height. In hypertrophy with dilatation the excursions of the lever of a Marey's sphygmograph often amount to several inches. In atrophy or degeneration of the heart's muscle the tracings become so tiny as to lose all detail and character, or vanish altogether. (It must be remembered that in some cases—as when the apex beats against a rib, or in violent dyspnœa—intelligible tracings cannot be obtained at all.) The effect of simple hypertrophy is mainly a broadening of the summit of the curve, owing to forcible systole and early closure of the valves (recorded by waves placed high up, near the apex, before the lever has descended much). Dilatation with hypertrophy tends to produce curves of great magnitude, the apex very high and pointed, followed by a considerable fall of the lever before the valves close, as in Fig. 3206. The size of car-

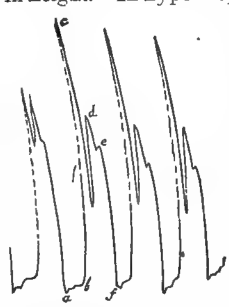

FIG. 3206.—Hypertrophy and Dilatation of Left Ventricle in a Case of Aneurism of the Thoracic Aorta. Pulse-rate, 90. (Marey's sphygmograph.)

* According to the interpretation of Landois. More accurately, I think, the moment of closure of the valves is represented by the notches preceding the waves d and e.

† In a case of phthisis (chronic pneumonia with cavities, fatty degeneration of right heart, chronic interstitial nephritis) without valvular lesions, in which the second sound was very distinctly reduplicated, Maurer (Deutsches Arch. f. klin. Med., 1879, Bd. 24) measured the interval between d and e = .156 sec., while in a number of normal cardiograms he found it to equal only .092 sec.

* The interpretation here given of the details of the cardiogram is that of (Marey and) Landois, adopted by many cardiographers,[40] especially German and French. Some English authors (*e.g.*, Bramwell) still follow the labored interpretation of Garrod,[41] or the equally artificial one of Galabin,[42] who places the beginning of the systole in about the middle of the up-stroke, where he recognizes a small rise (in some of his curves) as the expression of the closure of the auriculo-ventricular valves, and the end of the systole at the foot of, or at some point in, the main descent (between e and f), where he sometimes finds a small notch as the indication of the closing of the aortic valves. The waves in the plateau (from c to e) are explained (d) as due to "recoil toward the apex of the blood, which had been forcibly impelled against the auriculo-ventricular valves at the moment of their closure," and (e) to "locomotion of the heart as a whole," or "to the jerking forward of the apex at the end of systole." Keyt divides the curve into systolic and diastolic portions at exactly the same points as Landois, but recognizes no indication of valve-action, and explains the elevations of the systolic portion by variations in blood-pressure and muscle-contraction of the ventricles.

diographic curves must be studied with reference to the frequency and rhythm of the beat.

The auricular portion of the curve, *a b*, is well developed in proportion to the systolic elevation in cases of hypertrophy and overaction of the auricles, abrupt rise and increased height of the first denoting great force of auricular contraction. When the auricle is both large and strong, the curve may rise suddenly into a sharp peak, with a quick descent down to the point *b*, as in Figs. 3207 and 3208. Rough presystolic murmur—the purring thrill of mitral stenosis—is often pictured in this portion of the curve as a serrated line. (Compare Fig. 3212.)

FIG. 3207.—Valvular Lesions; Mitral Regurgitation Predominating. (Marey's sphygmograph.) (The first curve is very imperfectly reproduced, but both show plainly the violent auricular systole.)

The height of the ventricular upstroke, *b c*, is proportioned to the distinctness of the apex-impulse. It is invariably great in excentric hypertrophy of the left ventricle, especially so in aortic valvular disease and in combined lesions in which aortic insufficiency predominates. (Compare Figs. 3206, 3213.) The apex in such cases is apt to be very sharp, the first descent from it, abrupt.

The valvular elevations in the descent, or following the apex, indicate the tension in the aortic and pulmonary systems. Increased height of the elevations *d* and *e* denote, not only high tension in the respective vessel, but also testify to its elasticity and tone. When the latter properties are impaired by long-continued high pressure, dilatation, or atheromatous change, these waves are delayed and small. In some cases the rise of tension in the pulmonary artery, of which increased loudness of the

FIG. 3208.—Mitral Regurgitation. (Marey's sphygmograph.)

pulmonary second sound gives evidence, is well shown in the cardiogram by an earlier and higher wave, *e*, sometimes an early sign in mitral disease; if the blood-pressure in the aorta is lowered at the same time, *d* may be so far delayed that the two elevations *d* and *e* are merged into one, as in Fig. 3208.

Diseases of the right heart and obstruction of the pulmonary circulation affect the cardiogram only by the al-

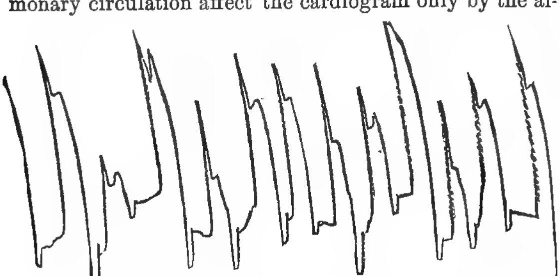

FIG. 3209.—Mitral Regurgitation. (Marey's sphygmograph.)

tered size and force of the right chambers, as above mentioned, and by the altered tension in the pulmonary artery. Valvular disease of the left heart is often expressed in more characteristic changes.

Mitral Regurgitation commonly shows a marked auricular portion, *a b*, as in Figs. 3207, 3208, 3210, owing to dilatation and energetic systole of the left auricle; a small aortic wave, *d*, on account of the lowered tension in the aorta, and a large and higher-placed pulmonary wave, *e*, as in Fig. 3210, on account of the increased tension in the pulmonary artery (loud second sound); the latter wave may be enlarged and hastened so much that it coalesces with the aortic wave, as in Figs. 3208 and 3209. The height of the whole curve is proportioned to the degree of enlargement of the heart. Comparing the cardiogram with the simultaneous sphygmogram (on polygraph or Keyt's sphygmograph), the presphygmic interval is found abnormally long.

FIG. 3210.—Mitral Insufficiency, after Maurer. (Marey's cardiograph.)

In *Mitral Stenosis* the auricular portion is lengthened (*i.e.*, of longer duration), and its tracing is higher, because the left auricle is dilated, contracts with force, and

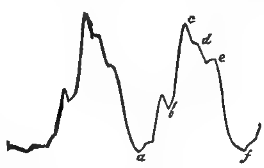

FIG. 3211.

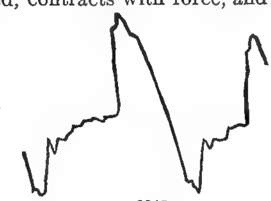

FIG. 3212.

FIG. 3211.—Mitral Stenosis, after Galabin. Pulse-rate, 80. (Galabin's cardiograph.)

FIG. 3212.—Mitral Stenosis (long, rough, presystolic murmur), after Galabin. Pulse-rate, 57. (Galabin's cardiograph.)

empties itself with difficulty; it often bears a series of wavelets, giving it a serrated appearance, corresponding to the purring thrill felt by the hand. In the systolic portion the increased blood-pressure in the pulmonary artery makes the wave *e* conspicuous. In case of reduplication of the second sound, the waves *d* and *e* are separated by a longer interval; Ott and Haas[43] attribute the late closure of the pulmonary valves to the diminished elasticity of the artery in consequence of long-continued high pressure in it.

Aortic Incompetency alters the apex-tracing chiefly through the factors of dilatation and hypertrophy of the left ventricle; the curve is very high, its apex pointed, the descent sudden; the pulmonary elevation is apt to be conspicuous, higher than the aortic elevation, sometimes, indeed, enormous, as in Fig. 3214, which reproduces a tracing taken, not at the apex, but nearer the pulmonary area. The auricular portion of the cardiogram is not changed in pure aortic insufficiency; sometimes its second wave (near *b*) becomes very distinct, as in Fig. 3214. In free regurgitation the presphygmic interval is shortened; the radial pulse follows so quickly upon the car-

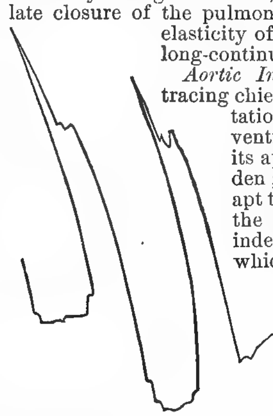

FIG. 3213.—Aortic Insufficiency, after Maurer. (Marey's sphygmograph.)

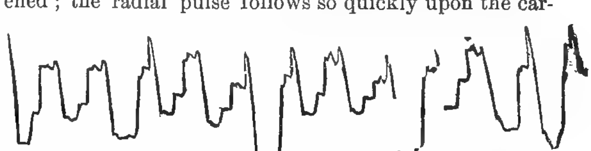

FIG. 3214.—Aortic Regurgitation; Great Dyspnœa. (Tracing taken in fifth intercostal space, one and one-half inch inside of apex-beat.) (Marey's sphygmograph.)

diac impulse that this phenomenon becomes a valuable diagnostic sign.

Aortic Stenosis is said to make the primary ascent small and slow (sloping), and the plateau of the systolic portion large, sometimes rising toward the end of the systole, sometimes, also, marked by irregular denticulation, answering to the harsh systolic murmur (Landois). The total systole is abnormally long.

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PULSE, VENOUS. In peripheric veins a pulsation has been observed, in exceptional cases, which is simply the arterial pulse carried forward through the capillaries into the veins. A necessary condition for this pulsation is, probably, wide dilatation of the minute arteries of the part, either by active vaso-dilatation (as in the case of the secreting salivary gland) or by paralysis. In a more limited and stricter sense, the name "venous pulse" refers to pulse-movements occurring in the large veins near the heart, especially the jugular veins, both in health and in disease.

1. NORMAL.—Pulsation of the jugular veins has long been known as a pathological phenomenon, but the demonstration of a venous pulse in health is of recent date. Potain,[1] in 1867, published a sphygmogram of a jugular pulse from a person in health. Mosso[2] showed that there is a physiological pulse in the jugular veins which can often be observed in healthy persons, and that this normal venous pulse is negative, *i.e.*, the reverse of an arterial pulse. Riegel[3] and Gottwalt[4] further proved that a jugular pulse is a constant normal phenomenon in dogs and rabbits; the same pulsation can be observed in many other veins, especially in the territory of the inferior vena cava. The older clinicians who had met with this jugular pulse in man, in the absence of valvular disease of the heart, had not been able to explain it without assuming an insufficiency of the valves of the jugular veins. Mosso, first showing the negative character of it, connected it with the "negative pulse of the thorax." Riegel explains it in the simplest manner by the varying velocity with which the blood of the jugular veins flows into the right auricle during the different phases of the heart's movements. It is approximately an inverse arterial pulse, making a descent synchronous with the cardiac systole, an ascent with the ventricular diastole and auricular systole. When the ventricle contracts (auricular diastole), the flow of venous blood is accelerated, causing a systolic venous collapse; but during the diastole of the ventricle, and especially during the auricular systole, the venous flow is retarded, causing a diastolic swelling of the jugular veins. Obviously, this process does not require for its consummation an insufficiency of the venous valves.

Graphic reproduction of this pulse shows a curve the ascent of which is commonly interrupted by a wave, while the descent is uninterrupted; the curve is "anadicrotic, catamonocrotic." The first part of the ascent corresponds to the diastole of the ventricle, the second ascent to the systole of the auricle, the descent to the systole of the ventricle.

2. PATHOLOGICAL.—The jugular pulse seen in heart disease is of different character and origin. Contrary to the normal negative venous pulse, it is a positive one, *i.e.*, its ascent is synchronous with the cardiac systole; and it depends upon a centrifugal movement, a regurgitation of the blood. This can occur only when the tricuspid valve is insufficient, and therefore it is a pathognomonic sign of tricuspid regurgitation—whether the insufficiency be due to inflammatory disease of the tricuspid, or to dilatation of the right heart consequent on disease of other valves. This pulsation may be confined to the lower portion of the vein, below the first set of venous valves; but when the vein is distended and (or) its valves are incompetent, the positive jugular pulse extends higher up into the vein. The regurgitation extends into the hepatic veins also, where it causes throbbing or pulsation of the liver synchronous with the cardiac impulse. Whenever the phenomenon is well developed it is not only distinctly visible, especially in the right external jugular, but equally palpable and accessible to the sphygmograph, sometimes yielding a tracing of great amplitude. Yet neither does the venous pulse occur in all cases of tricuspid insufficiency, nor is the amplitude of the pulse-wave in the jugular vein an indication of the degree of the valvular defect. The form of the sphygmographic curve is similar to that of the negative pulse, anadicrotic. *The criterion of the venous pulse of tricuspid insufficiency is the time of its occurrence; it is systolic. The normal venous pulse is presystolic* (Riegel).

The latter is sometimes—in cases of over-distention of the right heart, but with competent tricuspid valves—exaggerated, and is then visible as a presystolic swelling of the jugular bulbus. Confounding this *presystolic jugular pulse* with the systolic venous pulse of tricuspid regurgitation has caused much difficulty of interpretation and much confusion on the subject.

Absence of venous pulse in the presence of extreme

venous congestion has been held [5] diagnostic of tricuspid stenosis.

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[3] Riegel: Berlin. klin. Wochenschr., 1881.
[4] Gottwalt: Arch. f. d. gesammte Physiologie, Bd. xxv., 1881.
[5] Chauffard: Revue de Méd., July, 1884; Practitioner, December, 1884, p. 448.

PUMPKIN-SEED (*Pepo*, U. S. Ph.). The seed of *Cucurbita pepo* Linn., order *Cucurbitaceæ*, the common Pumpkin; a vine scarcely known in the wild state, but probably of Asiatic origin. It has been cultivated from time immemorial for its edible fruits. Its seeds, as well as those of other species—gourds, squashes, and cucumbers—have long been considered to have medical properties (*les grosses et les petites semences froides*), but their present employment as tænicides is of rather modern origin.

The seeds of several species and of numerous varieties of pumpkins, squashes, etc., are very similar in appearance, and are probably supplied in the market somewhat indiscriminately; the officinal description will serve to eliminate some of them: "About three-quarters of an inch (two centimetres) long, broadly ovate, flat, white or whitish, nearly smooth, with a shallow groove parallel to the edge; containing a short, conical radicle and two flat cotyledons; inodorous, bland, and oily." The testa is tough and flexible, and must be removed when the seed is prepared for use; the embryo is exalbuminous and has a pleasant, nutty, sweetish, oily taste.

Pumpkin-seed, besides *sugar, mucilage, albuminous substances, ferments*, and *asparagin*, contains twenty-five or thirty per cent. of a pale yellow, thickish, almost non-drying, odorless, and tasteless *fixed oil*, composed of glycerides of *oleic, palmitic, myristic*, etc., *acids*, and some free acids. The medicinal power is contained in the oil, but has never been separated.

USE.—This seed is a moderately efficient, agreeable, and entirely safe agent for the destruction of tape-worms. It should be preceded by the usual preparatory fasting (see Koosso), and be followed by a cathartic. It is not quite so certain as koosso and pelletierine, but is much less disagreeable than the former. Pumpkin-seed appears to vary considerably in its activity, probably in consequence of coming from different varieties or different conditions of cultivation. That of the West Indies and other southern countries is probably the best.

The usual method of administration is as an emulsion, made by pounding and rubbing the peeled kernels in water; from thirty to fifty grammes (before peeling) is the usual dose. The oil, if attainable, would no doubt be a better form.

ALLIED PLANTS.—See COLOCYNTH.

ALLIED DRUGS.—See KOOSSO.

W. P. Bolles.

Climate of Punta Rasa, Fla.—Latitude 26° 36′, *Longitude* 82° 10′.—*Period of Observations, September* 1, 1871, *to June* 15, 1883.—*Elevation of Place of Observation above the Sea-level*, 2 *feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	60.6	69.8	63.7	64.7	69.6	60.0	71.3	58.6	81.5	74.0	53.0	33.0	22	25
February...	62.1	71.3	65.4	66.2	70.7	62.8	73.2	60.3	84.0	75.0	52.0	43.0	22	25
March......	64.8	73.5	67.6	68.6	72.5	64.7	76.1	62.7	85.0	80.0	55.0	38.0	22	27
April.......	70.2	77.2	71.6	73.0	76.3	69.5	79.9	66.5	88.0	82.0	68.0	46.0	19	27
May........	74.6	81.0	74.2	76.6	79.3	75.3	83.6	69.8	92.0	85.0	65.0	57.5	19	19
June........	79.8	83.6	78.0	80.4	81.7	79.1	87.5	74.3	94.0	89.0	72.0	67.0	25	19
July........	80.6	84.2	79.1	81.3	82.9	80.3	88.9	75.9	93.0	91.0	73.0	67.5	23	25
August.....	80.2	83.9	79.0	81.0	83.0	79.5	88.0	75.7	93.0	91.0	73.0	70.0	18	22
September..	78.6	83.3	78.3	80.0	81.9	78.8	86.8	74.9	92.0	89.0	72.0	67.0	20	23
October.....	72.4	79.9	73.7	75.3	77.3	72.0	82.7	71.2	89.5	85.0	69.0	54.0	22	23
November..	66.0	74.5	68.4	69.6	73.3	66.2	77.1	64.1	87.0	81.0	51.5	37.0	18	24
December..	60.3	69.8	63.5	64.5	70.2	59.9	71.9	58.4	82.5	75.0	56.0	34.0	24	31
Spring......	......	......	......	72.7	74.3	70.2	....	....	......	......	......	......	......	......
Summer....	......	......	......	80.9	82.3	79.8	....	....	......	......	......	......	......	......
Autumn....	......	......	......	74.9	76.4	72.7	....	....	......	......	......	......	......	......
Winter......	......	......	......	65.1	68.8	62.2	....	....	......	......	......	......	......	......
Year........	......	......	......	73.4	74.2	72.5	....	....	......	......	......	......	......	......

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind, in miles, per hour.
						Inches.	From	Miles.
January....	48.5	77.6	15.0	9.8	24.8	2.26	N.E.	10.2
February...	41.0	75.3	11.4	11.5	22.9	1.72	N.E.	10.7
March......	47.0	72.1	11.8	14.7	26.5	1.30	N.E.	12.0
April.......	42.0	72.0	14.8	12.1	26 9	2.01	E.	12.1
May........	34.5	71.6	16.5	8.8	25.3	3.61	E.	10.4
June........	27.0	74.4	17.5	4.3	21.8	4.97	E.	8.9
July........	25.5	75.7	20.4	3.4	23.8	7.22	E.	8.2
August.....	23.0	77.1	19.4	2.6	22.0	7.38	E.	8.4
September..	25.0	77.7	18.4	3.4	21.8	7.23	N.E.	8.7
October.....	35.5	74.5	14.7	9.8	24.5	3.08	N.E.	11.1
November..	50.0	75.0	13.4	10.4	23.8	1.48	N.E.	10.1
December..	48.5	75.3	12.8	12.1	24.9	1.28	N.E.	10.3
Spring......	54.0	71.9	43.1	35.6	78.7	6.92	E.	11.5
Summer....	27.0	75.7	57.3	10.3	67.6	19.57	E.	8.4
Autumn....	55.0	75.7	46.5	23.6	70.1	11.79	N.E.	10.0
Winter......	51.0	76.1	39 2	33.4	72.6	5.26	N.E.	10.4
Year........	61.0	74.9	186.1	102.9	289.0	43.54	N.E.	10.1

PUNTA RASA, FLA. The accompanying chart, obtained from the Chief Signal Office, at Washington, represents the climatic conditions observed at Punta Rasa, a little hamlet situated near the mouth of the Caloosahatchee River, on the Gulf coast of Florida, about one hundred and seventy miles S.S.E. of Cedar Keys, and one hundred and twenty miles N. of Key West. As may be seen by carefully comparing the charts for these three

places, the winter climate at Punta Rasa is in character intermediate between that of Cedar Keys and that of Key West, except that, in respect to the humidity of its atmosphere, it is drier than either of the other places. The temperature of the sea-water at Punta Rasa is such as to admit of sea-bathing all the year round. As a winter health-resort, Punta Rasa appears to be as yet but little developed; under proper management and with intelligent sanitary supervision, it is likely to become a useful and favorite resort for such as require a very decidedly mild winter climate. (See article Florida, in vol. iii. of this HANDBOOK; and also Dr. J. C. Wilson's "Remarks upon the Climate of Florida," read before the American Climatological Association in 1885, and published in the *New York Medical Journal* for December 19th of that year.) *H. R.*

PURGATIVES, OR CATHARTICS, are medicines which are used to produce alvine evacuations. According to their activity and power, they are divided into laxatives and mild and drastic purgatives.

Purgatives which act very gently, producing soft, feculent stools without notable irritation, are called *laxatives.* This term is also applied to more powerful purgatives when they are given in small doses, so as to act mildly (see Laxatives, vol. iv., p. 458.)

Purgatives which operate briskly, usually producing more or less fluid evacuations, sometimes with griping and tenesmus, but without serious irritation, are called *mild* or *simple purgatives.* To this group belong some of the salts of magnesium, sodium, and potassium, which, from their resemblance in chemical and physical properties, and in physiological action, are termed *saline* purgatives.

The term *drastic* is applied to those purgatives which operate energetically, producing numerous evacuations, and, in excessive doses, more or less gastro-intestinal irritation.

Purgatives which produce watery stools, especially the salines and some of the drastics, are called *hydragogues*, and those which cause the evacuation of large quantities of bile, *cholagogues.*

MODE OF ACTION.—All purgatives accelerate the peristaltic movements of the intestines. Radziejewsky carefully observed the rapidity of peristalsis in dogs, both before and after the administration of purgatives. In the normal state the movements of the small intestine were rapid, those of the large intestine very slow. After the administration of purgatives, the movements of both became much accelerated, but most markedly those of the large intestine.

It was assumed that purgatives especially the hydragogues, also induce a discharge of fluid from the intestinal mucous membrane. Experiments on animals at first seemed to show that this was an error. Thiry completely separated a portion of the small intestine from the rest of the bowel, without dividing its vessels and nerves, sewed up one end, which was returned into the abdominal cavity, and attached the open end to the wound in the abdominal wall. Into the cul-de-sac thus formed he introduced croton-oil, senna, and Epsom salt. No accumulation of fluid took place. Schiff experimented in a similar manner with aloes, jalap, and sulphate of sodium, and Radziejewsky with croton-oil and sulphate of magnesium, both with the same negative result. Radziejewsky also analyzed the fæces before and after the administration of purgatives. The evacuations produced by purgatives contained more water and sodium salts than normal fæces, and sometimes products of pancreatic digestion, but never as much albumen as should have been present if transudation of fluid from the intestinal blood-vessels had taken place. It was therefore concluded by these investigators, and is still maintained by some recent authors, that purgatives do not induce either transudation or increased secretion, and that the watery character of the stools results only from the greatly accelerated peristalsis, which interferes with the absorption of the fluid normally secreted.

But subsequent investigations yielded different results. Moreau introduced sulphate of magnesium into a portion of intestine isolated by means of two ligatures, and after some hours found a decided accumulation of fluid. Brunton, experimenting in a similar manner, found that croton-oil, gamboge, elaterin, and Epsom salt caused a decided accumulation of fluid. That the accumulated fluid was not a transudation was evident from the fact that it contained very little albumen. Brieger injected into an isolated portion of intestine very small quantities of colocynth. No accumulation of fluid took place, but the bowel was contracted and slightly reddened. Larger quantities of colocynth, as well as croton-oil, caused an accumulation of bloody fluid, with decided inflammation of the mucous membrane. After injecting calomel, senna, rhubarb, aloes, and castor-oil, Brieger found the bowel empty and firmly contracted. Sulphate of magnesium in very dilute solution caused no accumulation of fluid, but concentrated solutions of this salt, so also Glauber salt, caused very decided accumulation. That the fluid was a secretion, and not a transudation, was evident from the fact that it readily converted starch into sugar and dissolved raw fibrin.

Thus it has been found in experiments that sulphate of magnesium, sulphate of sodium, croton-oil, gamboge, colocynth, and elaterin, not only accelerate the peristaltic movements of the intestines, but also induce a secretion of watery fluid from the intestinal mucous membrane; and that castor-oil, rhubarb, aloes, senna, calomel, and minute quantities of colocynth accelerate peristalsis, but do not notably increase secretion.

Hess, in experiments on dogs, endeavored to determine the manner in which purgatives increase the peristaltic contractions. He made gastric fistulæ a short distance from the pylorus, so that he could easily introduce purgatives into the duodenum. After having determined the quantity of the purgative (sulphate of sodium, castor-oil, croton-oil, senna, colocynth, gamboge, and calomel) which would act briskly, he introduced into the duodenum a small, empty india-rubber balloon, to which was attached a long, fine india-rubber tube. After this had been carried by the normal peristaltic contractions a certain distance, which varied in the different experiments, he filled it with water to such a degree as to obstruct the bowel. The purgatives which previously had acted briskly then completely failed. Hess therefore concluded that the peristaltic movements excited by purgatives are probably not propagated through long distances by means of nervous apparatus, or, according to Engelmann, from muscle to muscle, but that they are reflexly excited in each part of the intestine by direct stimulation of its mucous membrane.

MILD PURGATIVES.—Of the purgatives which act vigorously, without causing severe irritation of the intestines, the following are commonly employed: aloes, rhubarb, senna, castor-oil, salines, and mercurials.

Aloes.—In large doses, from five to twenty grains, aloes produces semiliquid or liquid stools. The first evacuation rarely occurs before six hours, and often not before ten or twelve hours. Some griping usually precedes the evacuations, and they are often attended by a feeling of heat in the anus, and by straining, especially if the medicine be repeatedly taken. From the slow action and the tenesmus, it is supposed that aloes influences the rectum more than other parts of the intestines.

In experiments on rabbits, Kohn found that aloes caused moderate hyperæmia of the stomach, intestines, and kidneys. In various animals large doses of aloin, injected into the subcutaneous tissue, were followed by gastritis, sometimes with hæmorrhage and ulceration, and in dogs and rabbits by degeneration of the epithelium of the kidneys.

According to the experiments of Rutherford, aloes increases the secretion of bile, and renders it more watery. Various observers have found that it does not act when bile is absent from the intestines.

Aloes was formerly employed in large doses to produce brisk purgation, when acute disorder of any organ of the body supervened soon after the cessation of an habitual hæmorrhoidal discharge. It was sometimes

given to produce a revulsive effect in cases of congestion of the brain, apoplexy, hemiplegia, and insanity. At the present time it is rarely used, except in small doses as a laxative. According to G. B. Wood, it sometimes quickly cures jaundice when other remedies have failed.

Aloes is contra-indicated in inflammatory affections of the intestines and kidneys, in irritable and bleeding piles, in uterine hæmorrhage, and during menstruation.

It is generally administered in pillular form, and the officinal *pills of aloes* are preferable to other preparations. Each pill contains two grains of aloes.

Rheum.—In doses of thirty to forty grains, taken at once, or ten to twenty grains, repeated several times at short intervals, rhubarb produces semiliquid stools in from five to ten hours, usually with griping, but without severe irritation. Some constipation generally follows. Recent experiments have confirmed the ancient opinion that rhubarb increases the secretion of bile.

Rhubarb is a suitable purgative when the bowels require thorough evacuation in patients who are occasionally subject to diarrhœa. Sometimes it is preferred to other purgatives in catarrhal jaundice.

It may be given in the form of powder, fluid extract, tincture, or wine. Aromatics are generally associated with it to prevent its griping effect. ℞. Pulv. rhei, ℈ij.; pulv. aromatici, ℈j. M. Div. in pulv. iv. Sig.: One powder every two hours. They may be conveniently taken in syrup or molasses, or in wafers. The fluid extract is given in doses of fifteen to thirty minims, mixed with syrup and an aromatic water. ℞. Extr. rhei fluid., ʒ jss.; syr. zingiberis, ℥ ss.; aq. cinnam., ℥ jss. M. Sig.: One tablespoonful every two hours till the bowels move. The tincture and wine are suitable for feeble patients, especially if they are accustomed to alcoholic beverages, and may be given in doses of half an ounce, repeated, if necessary, at convenient intervals.

Senna.—Senna operates gently and slowly in doses of fifteen to thirty grains, producing one or two pultaceous stools in from five to ten hours. Large doses act more briskly. Two or three drachms usually produce semifluid discharges in three or four hours. The evacuations are preceded by pretty severe tormina, and sometimes by nausea and eructations. Borborygmi and occasional small fluid stools often continue for from twelve to twenty-four hours.

Though it acts vigorously, and produces quite liquid stools, containing about eighty-five per cent. of water, senna never causes severe irritation or inflammation of the intestines. It is supposed, however, that large doses may influence the uterus, and, given during pregnancy, induce hæmorrhage and abortion.

The watery character of senna stools is generally regarded as evidence of increased intestinal secretion; but in careful experiments Brieger found no accumulation of fluid in an isolated loop of intestine with which senna had been in contact some hours. That it greatly accelerates the peristaltic contractions of the small intestine appears from Radziejewsky's experiments. This investigator found that in dogs, normally, from seven to nine discharges took place from a fistula in the ascending colon in three or four hours after a feeding; but when senna was administered the discharges began in ten or fifteen minutes, and numbered about thirty in four hours.

Cathartic acid, the active principle of senna, in doses of two to five grains, produces thin stools with colicky pains in from three to fourteen hours. Two grains, injected into the subcutaneous tissue, were followed by copious evacuations in from eight to twelve hours.

As senna acts rapidly and efficiently, it is suitable when the contents of the intestines require speedy removal. Combined with Epsom salt, as in the officinal compound infusion of senna, it is frequently employed in the early stage of inflammatory diseases, except those of the alimentary canal. It is better adapted than rhubarb and some other mild purgatives for patients disposed to costiveness.

Senna, in large doses, is contra-indicated in inflammation of the intestines, hæmorrhoids, menorrhagia, threatening abortion, and prolapse of the uterus or rectum.

It is generally given in the form of the *infusum sennæ compositum*, which, in quantities of about two ounces, repeated several times at intervals of one or two hours, soon produces copious watery discharges. The fluid extract of senna may be given in doses of half a drachm to two drachms with syrup and an aromatic water. ℞. Extr. sennæ fluid., ℥ ss.; syr. zingiber., ℥ ss.; aq. cinnam., ℥ iij. M. Sig.. A tablespoonful every hour until the bowels act. The syrup of senna is a convenient preparation for children in doses of one to four drachms.

Oleum Ricini.—Castor-oil, in doses of half an ounce to an ounce, usually produces semifluid evacuations in from three to six hours, generally with little or no griping or other symptoms indicating irritation of the intestines. Nausea and vomiting may occur in very susceptible persons, especially if the oil is rancid or the stomach disordered.

From its efficient and speedy operation, castor-oil is well adapted to all cases requiring a thorough cleansing of the alimentary canal, as when the presence of poisons, undigested food, or products of decomposition in the intestines indicates the use of a brisk purgative. Its gentle, unirritating action renders it suitable when a purgative is required in inflammation of the intestines, inflamed hæmorrhoids, fissure of the anus, metrorrhagia, and after parturition. For methods of disguising its taste, see vol. iv., p. 459.

Saline Purgatives.—The following saline purgatives are commonly employed: Sulphate of magnesium, sulphate of sodium, citrate of magnesium, tartrate of potassium and sodium, and bitartrate of potassium.

Large doses of saline purgatives produce copious watery stools. This peculiar action was explained by chemists as resulting from osmosis, the dense saline solutions within the intestines causing the less dense fluid of the blood to pass through the walls of the blood-vessels. But the fact that large doses of salines, when given in very dilute solution, so as to be less dense than the fluid of the blood, act as efficiently and often more speedily than concentrated solutions proved that this theory was untenable. Subsequently it was shown, by Buchheim and others, that only salts of low diffusibility are efficient purgatives, and that this property impedes their absorption in the intestines, causing them to pass nearly entire into the lower part of the large bowel and to excite purgation.

For a time it was supposed that the accelerated peristalsis resulting from the presence of saline solutions was sufficient to explain their rapid and peculiar action. But the investigations of Moreau, Brunton, Brieger, Hay, and others, have conclusively shown that dense saline solutions produce an active secretion of watery fluid from the intestinal mucous membrane. Brieger and Hay found that very dilute solutions, although they may purge rapidly, do not cause an increase of secretion; and Hay observed that when concentrated solutions are given, the quantity of fluid secreted depends upon the degree of concentration. Solutions containing less than five per cent. of a salt, produce little or no secretion, but stronger solutions always have this effect. Under ordinary circumstances, the amount of fluid secreted corresponds very nearly to the quantity required to form a five per cent. solution of the amount of salt administered. In consequence of the secretion of a large quantity of fluid, when concentrated saline solutions are given, the fluid of the blood becomes proportionately diminished. This continues only a short time, as the blood absorbs fluid from the tissues until it has nearly regained the quantity lost by increased secretion.

Thus the mode of action of saline purgatives depends upon the quantity administered and the degree of dilution. Very dilute solutions excite no intestinal secretion, but rapidly produce watery stools; while concentrated solutions cause a decided increase of secretion, diminish the fluid of the blood, excite absorption of fluid from the tissues, and in a short time produce watery evacuations.

Saline purgatives are preferred to other mild cathartics to evacuate inspissated fæcal masses. As a rule, they should be given in very dilute solution. In the early stage of inflammatory diseases, salines are often employed for the purpose of lowering temperature and blood-pressure, and thus diminishing the inflammation. They are of little use in such cases unless given in concentrated solution, so as to excite a decided increase of the intestinal secretion. The utility of salines is most conspicuous in cases of ascites and general dropsy. Administered in very concentrated solution, they often in a short time produce a very notable effect, especially if the patient have entirely abstained from food and drink for some hours before taking the saline.

Magnesii Sulphas.—Epsom salt is generally preferred to other saline purgatives. In doses of half an ounce to an ounce it usually produces watery stools in several hours, the first discharge sometimes taking place in one hour. This rapid action is rarely attended by severe griping. As it is readily soluble in water, it may be given in very concentrated solution, a method strongly recommended by Hay in cases of dropsy. It is frequently associated with senna, as in the compound infusion of senna.

Its taste is somewhat improved and its activity increased by sulphuric acid. ℞. Magnesii sulph., ℥ j.; aq. destill., ℥ ij.; acid. sulph. arom., ʒ ss.; syrupi., ℥ j. M. Sig.: One or two tablespoonfuls every hour. The bitterness of Epsom salt may be disguised by strong coffee and aromatics, especially cinnamon-water. ℞. Magn. sulph., ℥ j.; aq. cinnam., ℥ iij.; syr. aurant., ℥ j. M. Sig.: A tablespoonful every hour.

Sodii Sulphas.—Glauber salt has a still more repulsive taste than Epsom salt. It is therefore rarely employed when saline purgatives are indicated. According to recent researches, it causes a decided increase of the secretion of bile and renders it more watery. In all other respects its action closely resembles that of Epsom salt. The following substances have been employed to correct its disagreeable taste: Lemon-juice, aromatic sulphuric acid, carbonated water flavored with syrup, and extract or fluid extract of licorice.

Sulphate of sodium is the principal constituent of Carlsbad water and of the Carlsbad salt of commerce. According to W. Jaworski ("Ueber Wirkung, therapeutischen Werth und Gebrauch des neuen Karlsbader Quellsalzes," Wien, 1886), the natural Carlsbad *Quellsalz* contains from 46 to 47.5 per cent. of sulphate of sodium, from 33.5 to 36 per cent. of bicarbonate of sodium, and from 16 to 17 per cent. of chloride of sodium.

Carlsbad water has been found useful in catarrhal affections of the alimentary canal, habitual constipation, catarrhal jaundice, inspissation of bile and gall-stones, fatty liver, cirrhosis of the liver, and excessive obesity.

According to Jaworski, the natural Carlsbad *Quellsalz* is most advantageously employed as follows: It should be taken in the morning, immediately after rising, in sufficient water to form a two per cent. solution. The dose of the salt may vary from five to fifteen grammes (ʒ j.–iv.). As an occasional purgative the dose is ten grammes (ʒ ijss.), which should be taken in cold water or soda-water. Used methodically in habitual constipation, the dose should not exceed ten grammes, and should generally be less, and be taken in cold water. In catarrhal jaundice, from ten to fifteen grammes, dissolved in warm water (30° to 40° C.), should be taken daily for at least two weeks.

Liquor Magnesii Citratis.—The solution of citrate of magnesium has an agreeable taste, and is therefore often preferred to other saline purgatives to unload the bowels in simple constipation. It is, however, less efficient than the sulphates of magnesium and sodium, sometimes operating briskly, sometimes producing no purgative effect. Usually a whole bottle, containing twelve ounces, taken in several portions at short intervals, is required. In cases of dropsy and inflammatory diseases other saline purgatives are preferable.

Potassii et Sodii Tartras.—In doses of half an ounce to an ounce, Rochelle salt usually produces liquid stools in a few hours. As it has a less disagreeable taste than Epsom salt, generally agrees well with the stomach, and acts gently, it is often employed when a mild purgative is indicated in the diseases of children, females, and delicate persons. It somewhat increases the secretion of bile. From two to four drachms, dissolved in sweetened water, may be taken at intervals of two hours till the bowels respond.

Potassii Bitartras.—Large doses of cream of tartar, half an ounce to an ounce, are followed by watery stools, which are often preceded by flatulence and griping. It is rarely used alone, but frequently in combination with jalap. When given in large doses, it should be suspended in an aromatic water to prevent griping.

Mercurial Purgatives.—Of the preparations of mercury which produce catharsis, calomel and blue mass are frequently used. Metallic mercury is sometimes employed in obstruction of the bowels.

Hydrargyri Chloridum Mite.—Calomel, in doses of from five to ten grains, usually acts in about six or eight hours, producing copious semiliquid, dark-brown or green evacuations. As a rule, no marked incidental effects are observed; but sometimes, especially after the larger quantity, the evacuations are preceded by griping, nausea, and depression. Smaller doses, one to three grains, act slower and very gently. Accurate chemical analyses have discovered in calomel stools bile-pigments, leucine, tyrosine, peptones, sulphide of mercury, and unchanged calomel, but no scatol and indol.

The presence of bile in the stools was formerly regarded as a certain evidence of an increased secretion of bile. But in numerous careful experiments on dogs, and in some observations made on patients having accidental biliary fistulæ, it was found that purgative doses of calomel notably lessen the secretion of bile. To explain the presence of bile in the stools notwithstanding diminished secretion, it was then assumed that calomel greatly increases the peristaltic contractions of the small intestine, especially of the duodenum, and thus hurries the bile already secreted downward so rapidly that reabsorption cannot take place. The presence of leucine and tyrosine in calomel stools rendered this view very plausible. But the fact that some purgatives, which act more rapidly than calomel, and doubtless strongly accelerate the peristaltic contractions of all parts of the intestines, do not produce markedly bilious discharges seemed to show that this assumption was incorrect.

The recent experiments of Wassilieff show conclusively that calomel produces bilious stools, by arresting decomposition in the intestines. He divided fresh ox-gall into three portions, each weighing two hundred grammes; to one portion were added three grammes of calomel, to another two grammes, and to the third none. They were kept in a warm room, and occasionally agitated. The portions containing calomel at once became green, and retained this color as long as the experiment was continued, which was six days. They readily responded to Gmelin's test for bile-pigment, and showed no trace of decomposition. The portion not containing calomel had become brownish-yellow in one day, did not exhibit the reaction of bile-pigment, and was soon putrid. Doubtless calomel exerts the same antiseptic influence in the intestines. Under ordinary circumstances the bile-pigments, bilirubin and biliverdin, become converted into hydrobilirubin, and hence cannot be detected in the fæces. Calomel prevents this decomposition, and by increasing peristalsis causes the unchanged bile-pigments to be evacuated. In the same manner it prevents further changes of leucine and tyrosine, and the formation of scatol and indol.

Calomel is a very effectual purgative in the morbid state called biliousness—marked by a sallow complexion, yellowness of the white of the eyes, a bitter taste, defective appetite, and sometimes nausea; headache, mental dulness, and depression; and sometimes by light-colored stools and sedimentary urine. By arresting decomposition and removing bile and other substances before they can be absorbed, it thoroughly relieves both the intestines and liver.

In small doses calomel has been found useful in the gastro-enteritis of children. Its utility is probably due chiefly to its antiseptic action.

Administered in doses of from five to seven grains, for one or two days, in the first week of typhoid fever, calomel somewhat lowers the febrile temperature and renders the disease milder. As other purgatives are less useful, it probably exerts a destructive influence upon the micro-organisms which cause the disease.

As a rule, calomel is indicated as a purgative in all acute affections of the intestines resulting from fermentation and putrefaction.

Together with jalap or rhubarb, it is sometimes administered in the early stage of inflammatory disorders of the internal organs. Though not useless, it produces very much less effect on the quantity of fluid in the blood-vessels and on the blood-pressure than large doses of the saline purgatives.

Calomel should not be used in habitual constipation.

It is usually ordered in powder with sugar, or with jalap, rhubarb, or bicarbonate of sodium. ℞. Hydrarg. chlor. mitis, gr. v.; sacch. albi, gr. x. M. Sig.: Take at once. ℞. Hydrarg. chlor. mitis, gr. iij.; pulv. jalapæ, gr. x. M. Sig.: Take at once in syrup or molasses. ℞. Hydrarg. chlor. mitis, gr. v.; sodii bicarbon., gr. xv. M. Sig.: Take in molasses or syrup. In all cases, if calomel have failed to act after eight or ten hours, a saline purgative or castor-oil should be given.

Massa Hydrargyri.—Blue mass is a somewhat uncertain purgative when given in doses of from five to ten grains. It is, therefore, usually combined with rhubarb, aloes, podophyllum, or compound extract of colocynth, or, if given alone, a dose of castor-oil, Rochelle salt, Epsom salt, a senna draught, or a seidlitz powder, is administered after eight or ten hours. It is held to be efficient in biliousness, and is usually given in the evening.

Hydrargyrum.—Metallic mercury in large doses quickly passes through the alimentary canal in consequence of its great weight. Probably the dragging and stretching of the mucous membrane, resulting from the presence of large quantities, excite very powerful peristaltic contractions, which rapidly carry the metal through the intestines.

Metallic mercury has been employed in intestinal obstruction when all other ordinary means had failed to give relief. Bettelheim (*Deutsches Archiv f. kl. Med.*, Bd. 32, p. 53) carefully studied seventy cases of obstruction, reported during the last fifty years, in which mercury was used. In fifty-seven cases a cure resulted, that is, the obstruction was relieved either temporarily or permanently. In no case did it cause rupture, inflammation, or gangrene of the bowel, while in some instances it saved life. Bettelheim therefore considers it proper to administer mercury in cases of obstruction due to fæces, ascarides, and even to intussusception or torsion, if other ordinary means have failed to give relief.

The dose of metallic mercury varies from one to ten ounces.

Drastic Purgatives.—Of the cathartics which operate violently and produce serious irritation of the intestines, when given in excessive doses, only the following are commonly employed: Jalap, scammony, colocynth, podophyllum, gamboge, croton-oil, and elaterin.

Jalapa.—Jalap is the mildest drastic, and resembles senna in its action. In doses of fifteen to thirty grains it usually soon causes a feeling of discomfort in the epigastrium, and sometimes nausea. After two or three hours tormina and several liquid stools occur. Smaller doses, five to ten grains, act gently, producing one or two pultaceous evacuations. In very excessive doses jalap causes vomiting and profuse rice-water discharges, with great depression.

The resin of jalap, in doses of one to three grains, acts as a laxative, but in larger doses, from five to fifteen grains, produces watery stools in a few hours.

According to recent investigations, jalap does not act well when bile is absent from the intestines. In experiments on dogs it was found to increase moderately the secretion of bile.

On account of its rapid, safe, efficient, and hydragogue action, jalap is frequently employed when a brisk cathartic is indicated. In cases of acute constipation, and in inflammatory diseases, it is usually associated with calomel, and in ascites and anasarca with bitartrate of potassium. The officinal *pulvis jalapæ compositus*, consisting of 35 parts of jalap and 65 parts of cream of tartar, is generally preferred to other hydragogues in dropsy. In doses of half a drachm to one drachm, it usually produces watery discharges in a few hours.

The resin of jalap may be given in doses of from one to eight grains in powder or emulsion. ℞. Resin. jalapæ, pulv. acaciæ, āā gr. viij.; sacch. albi, ʒ ss. M. Div. in part. æqual. iv. Sig.: One powder every two hours till the bowels move. ℞. Resin. jalapæ, gr. viij.; pulv. acaciæ, sacch. albi, āā ʒ j.; aq. menth. pip., ℥ ij. M. Sig.: One tablespoonful every two hours. Sometimes resin of jalap is given in combination with calomel. ℞. Resin. jalapæ, hydrarg. chlor. mitis, āā gr. iv.; sacch. albi, ℈ j. M. Div. in part. æqual. iv. Sig.: One powder every two hours.

Jalap is contra-indicated in inflammatory affections of the alimentary canal.

Scammonium.—Scammony resembles jalap in action, but is less certain, sometimes producing little or no effect, at other times acting harshly, with griping and tenesmus. Usually it is followed by watery stools in a few hours. The presence of bile in the intestines is necessary for its action. It is rarely used except in combination with other purgatives, as in the officinal *compound cathartic pills.* The dose of scammony, to act briskly, is from ten to twenty grains, and of its resin, from five to ten grains.

Colocynthis.—Large doses of colocynth produce numerous fluid evacuations, with griping and tenesmus. Excessive doses cause sanguinolent stools, great abdominal pain, intense depression, and sometimes death.

Small doses, one to three grains, act gently, producing loose stools without notable griping. But if frequently repeated, such doses soon cause tormina and tenesmus, and slimy stools.

According to Brieger, small quantities of extract of colocynth, 0.02 gramme dissolved in 2.0 grammes of water, injected into isolated portions of intestine, produce slight hyperæmia and peristaltic contraction, but no accumulation of fluid. But larger quantities produce decided inflammation and an effusion of bloody fluid.

In experiments on dogs Rutherford found colocynth to cause an increased flow of watery bile.

On account of its harsh operation, colocynth is rarely employed alone to produce brisk purgation; but in small doses, in combination with other laxatives, it is frequently given in habitual constipation.

The dose of the extract of colocynth, as a laxative, is one-sixth to two-thirds of a grain, and of the compound extract, from one to five grains. The latter preparation is sometimes given in doses of five to fifteen grains, to purge briskly. Usually the extract of hyoscyamus, or the extract of belladonna, is combined with it, to prevent griping. ℞. Extr. colocynth., gr. j.; aloes, gr. vj.; extr. hyoscyami, gr. vj. M. Ft. pil. vj. Sig.: One pill at bedtime. ℞. Extract. colocynth. comp., gr. xij.; extr. bellad., gr. ij. M. Ft. pil. vj. Sig.: One pill at bedtime.

Cambogia.—Gamboge is held to be still more irritant than colocynth. In experiments Rutherford found, after large doses, violent irritation of the duodenum and small intestine generally, with profuse catharsis, but no increase of the bile-flow.

It is, perhaps, never given alone, but is sometimes added to other purgatives to increase their action, as in the compound cathartic pills. Very small doses, one-sixth to one-half grain, are said to produce pultaceous stools without much griping. Generally doses of three to four grains cause some nausea and colicky pain, and several watery stools. Excessively large doses, one drachm, have caused fatal gastro-enteritis.

Formerly gamboge was frequently employed in obstinate constipation, ascites, anasarca, paralysis, insanity,

gout, and skin diseases. Generally it was given together with aloes, jalap, bitartrate of potassium, and calomel. ℞. Cambogiæ, gr. iv.; pulv. jalapæ comp., ʒ ij. M. Div. in pulv. iv. Sig.: One powder every two hours till the bowels act, in cases of dropsy.

Pilulæ Catharticæ Compositæ.—The compound cathartic pills contain small quantities of aloes, scammony, colocynth, jalap, gamboge, and calomel. On account of their complex composition they are supposed to affect all parts of the intestines, and to increase the secretion of bile. One pill usually acts as a laxative, while three or four produce free purgation. They are suitable to acute constipation not complicated with inflammation of the intestines, but should not be employed in habitual constipation.

Podophyllum.—This purgative, even in large doses, usually acts slowly, from six to ten hours elapsing before the bowels move. Doses of ten grains rarely cause marked incidental effects, but twenty or thirty grains are usually followed by nausea, and sometimes vomiting and depression, and severe colicky pain. The evacuations sometimes have a dark color, from which it was assumed that they contain a large quantity of bile. In experiments on dogs Rutherford found that moderate doses of podophyllin cause an increased flow of bile.

The resin of podophyllum, commonly called podophyllin, is used as a laxative. Doses of one-eighth to one-half grain usually produce a gentle movement in eight or ten hours. Large doses, from two to four grains, cause nausea, sometimes vomiting, severe griping, and numerous stools, which may be slimy and bloody and followed by intense depression.

Podophyllin is not suitable in cases requiring brisk purgation. But in chronic constipation it is much used, because it continues to act for a long time without necessitating an increase of dose. It is frequently employed when symptoms are present which show that the secretion of bile is abnormal. Usually it is given in pillular form, with extract of hyoscyamus or extract of belladonna. ℞. Podophyllini, gr. ij.; extr. hyoscyami, gr. viij. M. Ft. pil. No. viij. Sig.: One pill at bedtime. It has also been given in solution as follows: ℞. Podophyllini, gr. ij.; alcohol. dil., ℥ ij.; tinct. zingiberis, ʒ ij. M. Sig.: A teaspoonful in a wineglassful of water.

Podophyllotoxin is said to act more regularly than the officinal resin. It has been given to adults in doses of one-sixth to one-fourth of a grain, and to children in doses of one-sixtieth to one-twelfth of a grain. Brun employed it in alcoholic solution as follows: ℞. Podophyllotoxini, Gm. 0.05; spir. vini rectif., Gm. 7.5. M. Sig.: From five to fifteen drops in sweetened water.

Oleum Tiglii.—Croton-oil is a very energetic drastic, a drop sometimes producing from five to fifteen watery evacuations. Often the first evacuation occurs in one or two hours.

The susceptibility of different persons to its action varies, in some one drop acting intensely, in others producing only a few semiliquid stools. In rare instances purgation does not result from the dose mentioned, but there takes place general disorder, marked by palpitation of the heart, pain in the extremities, severe headache, giddiness, and prostration.

Frequently the action of croton-oil is attended by symptoms indicating irritation of the stomach and intestines—a sensation of heat in the epigastrium, more or less nausea, sometimes vomiting, borborygmi, colicky pain, and tenesmus.

Excessive doses quickly induce vomiting and purging, and great prostration. Twenty drops have proved fatal.

Croton-oil is used when a powerful purgative is indicated, and milder medicines have failed to act or cannot be administered. Sometimes this is the case in obstinate constipation, lead-colic, and diseases of the brain and spinal cord. When brisk purgation is necessary, and swallowing is very difficult, the oil is preferred to more bulky cathartics, a drop being mixed with a little sugar, or a little bread-crumb, and placed on the back of the tongue.

The oil has been strongly recommended for the removal of tape-worm—one drop mixed with one drachm of chloroform and one ounce of glycerine, to be given early in the morning.

Croton-oil is usually given in pillular form. ℞. Ol. tiglii, gtt. j.; micæ panis, q. s. M. Ft. pil. iv. Sig.: One pill every hour. It is said that the oil acts more gently when combined with compound extract of colocynth and extract of belladonna. ℞. Ol. tiglii, gtt. j.; extract. colocynth. comp., gr. viij.; extr. bellad., gr. j. M. Ft. pil. iv. Sig.: One pill every two hours. Sometimes it is given mixed with sugar. ℞. Ol. tiglii, gtt. j.; sacch. lactis, ʒ j. M. Div. in part. æq. iv. Sig.: One powder every hour. It may also be mixed with castor-oil, or made into an emulsion, as follows: ℞. Ol. tiglii, gtt. j.; pulv. acaciæ, ʒ ij.; syr. amygdalæ, ℥ ss.; aq. destill., ℥ iijss. M. Ft. emuls. Sig.: One tablespoonful every hour.

Elaterinum.—Elaterin is the most powerful and drastic of all purgative medicines. The twentieth of a grain, given to an adult, will generally produce watery stools in one or two hours. Sometimes this speedy action is not attended by marked incidental effects; but often, especially if it is given alone, nausea, severe griping, borborygmi, and some prostration are produced. Excessive doses may cause intense gastro-enteritis and fatal collapse.

Elaterin is employed in ascites and anasarca, when gentler hydragogues have failed to act efficiently. As a rule, it is given only every other day, and not continued longer than a week or ten days, lest it excite serious intestinal inflammation. After an interval of a week its use, if necessary, may be resumed. It is contra-indicated in dropsies complicated with intestinal irritation, and must be used with extreme caution in very young, aged, and feeble patients.

It may be ordered in solution, pill, or powder. ℞. Elaterini, gr. ½; alcohol., ℥ ss.; acidi nitrici, gtt. ij. M. Sig.: From twenty to forty drops in an aromatic water. ℞. Elaterini, gr. ¼; extr. hyoscyami, gr. vj. M Ft. pil. vj. Sig.: One pill every hour till stools take place. ℞. Elaterini, gr. ¼; sacch. albi, ʒ j.; ol. menth. pip., gtt. ij. M. Div. in part. æqual. vj. Sig.: One powder every hour until the bowels act.

General Indications.—Purgatives are used (1) to evacuate the intestines; (2) to diminish hyperæmia of remote parts or organs; (3) to promote the absorption of exudations and transudations; and (4) to eliminate noxious substances.

1. *All purgatives evacuate the contents* of the intestines; but when this is the sole indication for their use, only laxatives and mild purgatives should be given. In chronic or habitual constipation those laxatives are most suitable which act slowly, producing normal or nearly normal fæcal evacuations, without losing their activity in small doses after frequent repetition, and without interfering with general nutrition. Experience has shown that aloes possesses these properties in the most eminent degree. Podophyllin, rhubarb, and compound extract of colocynth are also eligible. The saline laxatives are sometimes used in habitual constipation; but as their prolonged use is followed by impairment of nutrition, they should not be given to feeble patients unless required by other indications.

In occasional or acute constipation any laxative or mild purgative may be employed. If hardened fæcal masses are present in the intestines, the saline laxatives and castor-oil are most suitable. Sometimes all the mild purgatives fail to act in acute constipation, especially when the cause of the constipation is still present, as in lead-poisoning. Drastics are then appropriate, carefully used, and croton-oil is usually preferred. Metallic mercury has been successfully used after all ordinary purgatives had proved ineffectual.

To remove poisons and irritating substances from the intestines, those purgatives which act speedily and gently should be preferred, especially castor-oil and salines. When irritation of the intestines results from decomposition or fermentation, calomel is the best purgative.

2. *To diminish hyperæmia* of remote parts or organs, purgatives which act rapidly and produce semiliquid or

watery discharges are required. Mild purgatives deplete indirectly by hastening the intestinal secretions and partially digested food downward so rapidly that absorption is impeded. Saline purgatives, in strong solution, excite a copious secretion of watery fluid, and thus directly deplete the blood. Drastics act in a threefold manner, accelerating peristalsis, increasing secretion, and exciting intestinal hyperæmia. The choice of a purgative will, therefore, depend upon the intensity and duration of the disease to be influenced, the organ affected, and the character of the general symptoms. In congestion of the liver, calomel, followed by a saline laxative, is the most suitable purgative. In congestion or inflammation of most organs, saline cathartics and compound infusion of senna are usually employed; but in very severe congestion or inflammation of very important organs—such as the brain and spinal cord—drastics are preferred, especially croton-oil.

3. *To promote absorption of exudations* and transudations, the hydragogues are most suitable. Generally the saline hydragogues, given so as to produce copious watery stools, soon cause rapid absorption. In cardiac dropsy they often diminish the dropsical swelling very notably in a few hours. Of the drastic hydragogues the compound powder of jalap and elaterin are the most useful. Generally the former is preferred on account of its mild action. But when it fails to act efficiently, or when an effusion of serum occurs rapidly, and in such large quantity as to produce extreme distress, such as alarming dyspnœa in pleuritis, elaterin is usually given. Sometimes it so rapidly induces absorption of the effusion as to give decided relief in a few hours.

4. *To eliminate noxious substances*, calomel, salines, and drastics are used. The utility of calomel in biliousness and congestion of the liver is in part due to the rapid removal of irritating and decomposing substances from the alimentary canal. Saline laxatives, especially sulphate of magnesium, are indicated in chronic lead-poisoning, to remove the poison from the intestines as fast as it is eliminated by the liver. They are also suitable in cases of uræmia, especially if at the same time it is necessary to induce absorption. In uræmic coma, croton-oil is sometimes preferred to milder purgatives.

CONTRA-INDICATIONS.—All purgatives are contra-indicated in peritonitis, intestinal hæmorrhage, perforation of the bowels, strangulated hernia, and extreme debility.

Brisk purgatives are generally inappropriate during pregnancy, especially if previous abortions have occurred, and during menstruation. They should not be used if there exist severe rectal lesions, or a tendency to looseness of the bowels. Even laxatives are contra-indicated in habitual constipation, until all other known means have failed to establish a normal habit of defecation.

Samuel Nickles.

PURPURA. A disease of the skin characterized by the development of variously sized and shaped, smooth, reddish or purplish hæmorrhagic patches, which may or may not be elevated above the surface, and which do not disappear under pressure.

The affection may conveniently be considered under two heads, *idiopathic* and *symptomatic* purpura.

IDIOPATHIC PURPURA is usually considered to include two varieties, P. simplex and P. hæmorrhagica, although these divisions (like those of idiopathic and symptomatic) are arbitrary, and the two varieties may run into each other with intermediate cases.

Purpura simplex is characterized by the appearance, in successive crops, of numerous petechial spots in the skin and visible mucous surfaces. These are usually attended with little or no constitutional disturbance. Occasionally, however, malaise, loss of appetite, and fatigue on exertion are experienced for some days before the cutaneous lesions appear. These generally make their appearance suddenly, often in the course of a night, at other times more gradually.

The lesions are usually bright red in color at first, becoming more purplish in hue later. They are sharply defined, roundish, ovalish, or irregular, sometimes circinate in form, and vary from the size of a pin-point to that of a pea or small coin. They usually occur in numbers and symmetrically, the lower limbs being a favorite seat, and in particular the flexor surface of the thigh. They may occur sparsely scattered over the whole body. Usually there are no subjective symptoms connected with the appearance of purpura simplex; occasionally there is a little itching on the first appearance of the spots, and they are not infrequently tender on pressure.

Purpura simplex is more frequently observed in the old than in the young. It may last from a fortnight to several months, or even longer, the lesions coming out in successive crops. The affection occurs in the well-nourished and apparently healthy, as well as in the debilitated.

The immediate cause of purpura simplex is not infrequently found in fatigue, exposure to damp and cold, moral shock, and occasionally malarial influences. The affection usually lasts a few weeks only, but may be prolonged for months, or even a year or more, by the appearance of successive crops of eruption.

Another form of idiopathic purpura is that known as *purpura urticans.* The eruption here shows itself first as a roundish papule, which gives place in a few hours to a purpuric macule, resembling in every respect the macule of P. simplex above described. Occasionally, however, a congestive or bright-red circle is seen surrounding the purpuric spot. The burning, itching, and tingling of ordinary urticaria are rarely present. On the other hand, there may be pains in the limbs, and, occasionally, articular swellings; and localized œdema, sometimes soft, at other times red and painful, is occasionally noticed about the joints or in the length of the limbs. The common seat of the lesions is upon the lower limbs. The eruption may be preceded or accompanied by slight general malaise, and occasionally some feverishness. It resembles closely in all other symptoms, course, etc., purpura simplex, excepting that it is frequently accompanied by sick headache (migraine), dyspepsia, congestion about the head, difficulties of sight and hearing, hæmorrhoids, and rheumatic pains.

Purpura rheumatica, or peliosis rheumatica (πελος, livid), is usually found occurring upon the lower limbs, about the tibio-tarsal articulations or the knees, and on the lower and inner aspect of the thighs. The eruption consists of petechiæ, more rarely of true ecchymoses, and is commonly symmetrical, although it is sometimes seen limited to a knee or an elbow. Urticaria-like papules are not infrequently observed co-existent with the petechiæ.

P. rheumatica may occur suddenly and without prodromes. Ordinarily, however, pricking, weight, and tension in the part to be affected precedes the appearance of the rash, which is accompanied by some rise of temperature, rarely above 101.3° F.

The articular pains are usually experienced in the insteps, the knees, and the carpal region. The effusion is slight, movement of the affected joints is painful, and pressure near the ligaments gives rise at times to sharp pain.

Œdema of the cellular tissue is often a marked feature of the disease. The skin becomes stretched, reddish, pits, and is painful on pressure. Sometimes the œdema is extreme and seems almost phlegmonous in character, with extensive ecchymoses. Soyer has given to this variety the name of *febrile purpuric œdema.*

Very exceptionally the rheumatic symptoms may become generalized, and even heart complications may follow, but usually we have purpura complicated with slight rheumatism. An acute, febrile, general rheumatism with purpura as an accompaniment is very uncommon.

Though purpura rheumatica is usually a comparatively slight malady, yet cases have been recorded in which hæmorrhage from the stomach and bowels, gangrene of the face, limbs, intestine, etc., have gravely complicated the attack.

The duration of the attack of purpura rheumatica is brief, but the disease may be, and usually is, prolonged by successive attacks for weeks, and even months. It usually terminates in recovery, and relapses are rare.

The affection is most apt to attack persons in whom a

rheumatic taint exists. Nervous exhaustion, privation, and exposure to cold are among the exciting causes.

Couty and Henoch have described a variety of purpura to which they attribute a nervous origin. This form of purpura is characterized by three symptoms: 1, a purpuric eruption; 2, gastro-intestinal disorder; 3, cutaneous œdema.

The eruption is petechial and makes its appearance suddenly, often assuming the urticarial form and involving by preference the limbs, particularly the lower limbs, the abdomen, the genitalia, and, exceptionally, the trunk and face. The extent of the lesions varies from one or two small spots to even sheets of eruption. The duration of the lesion is from four to six days. Successive attacks vary greatly in frequency and severity.

The gastro-intestinal disturbances are chiefly bilious vomiting, and successive attacks of colic, accompanied by retraction or inflation of the abdomen, and not followed by stools. These attacks of colic usually last only an hour or so, but may continue one or two days.

The œdema characteristic of this form of purpura may be peri- or intra-articular, and may occupy a greater or less portion of the limb. Sometimes the affected part is pale and painless, at other times it is red and painful. Occasionally gangrene supervenes. The various symptoms may occur in regular order in successive attacks, or they may be intermingled.

Under the name of *myelopathic purpura* Faisans has described a similar form of the disease, the cause of which he has traced back, in a number of cases, to some nerve disturbance, as chronic affections of the cord, transverse myelitis, secondary spinal cancer, and tuberculosis. Faisans lays stress upon the frequently urticarial form of the eruption, on its symmetrical occurrence, and on the possibility of the distribution of the spots along the course of the sensory nerves, similar to that of herpes zoster.

The arthralgia, in Faisans' opinion, is a marked symptom, and is peculiar with respect to its multiplicity and extreme mobility. The ankle, knee, wrist, and elbow are most frequently attacked, but all the joints may be involved in turn. The eruption in Faisans' cases usually was in close connection with the joint-trouble, being most marked in the neighborhood of the affected articulation. Hyperæsthesia and anæsthesia were observed in connection with the purpura. There was rarely fever. While Conty regards the gastro-intestinal attacks as analogous to those of lead colic, Faisans looks upon them as resembling the pains of locomotor ataxia. The latter also regards this form of purpura as rather of a medullary than of a sympathetic nervous origin. Faisans says that the attacks may follow acute hyperæmia of the posterior fasciculi of the cord, resulting in intense congestion of the skin, with trophic disturbance of the smaller vessels facilitating their rupture.

In this connection reference may be made to the interesting observations of Straus on tabetic ecchymoses. These ecchymoses appear in a certain number of ataxic patients, following severe attacks of fulgurating pains, and occur, like other forms of purpura, chiefly upon the limbs. The ecchymoses resemble contusions most closely, but are not painful upon pressure. They are irregularly circular in form, and vary from the size of a pea to that of a silver dollar. The number also varies from one to several upon each limb. Their extent seems to be dependent upon the severity of the previous attack of pain.

The seat of these tabetic purpuras is of interest. They are, as a rule, situated on the member or part which has been the chief seat of pain, usually not directly over the affected point, but on the proximal side. Occasionally the other side of the body, corresponding to that attacked by the pain, is the seat of the eruption. According to Straus, the lesions do not seem to be arranged along the lines of distribution of the nerves. Charcot, however, takes a different view.

As regards the frequency of tabetic purpura, Straus has observed it twice in twelve cases of locomotor ataxia.

Under the name of *purpura hæmorrhagica* has been described a group of cases having the one point in common, that the eruption on the skin has also been accompanied by hæmorrhages from the cavities of the body, but otherwise widely differing from each other in the symptoms presented. Recent writers are inclined to separate these cases, and assign the greater part to scorbutus, and the rest to the other divisions of purpura which have been, or are to be, here described.

The name of Werlhof, a German physician of the last century, having been given to this affection (morbus maculosus Werlhofii is the entire clumsy title), Lasègue took the trouble to look up Werlhof's original paper on the subject, in order to find out what that author had described. The affection described by Werlhof is characterized by the absence of fever, prodromal symptoms, or concomitant symptoms worthy of mention. The affection begins by a more or less considerable hæmorrhage, rarely profuse, usually from the gums, only occasionally from the nose. There is at this time no hæmatemesis or other visceral hæmorrhage. In the course of from twenty-four to forty-eight hours after the first symptoms, the eruption, more or less confluent, has spread over the lower limbs first, and then in some cases over the arms and trunk. The face is never attacked. The spots are punctate, indolent, and do not blanch under the pressure of the finger.

By the third day larger hæmorrhagic patches and suggillations occur upon the lower limbs, in some cases accompanied by ecchymoses on the mucous surface of the mouth. The hæmorrhages or hæmorrhagic exudations continue in variable quantity; if they are severe, blood may be vomited or passed at stools. Weakness with slight fever, diminution of appetite, and possibly lassitude without actual pain in the limbs, are observed. When the affection has thus reached its height, rapid improvement takes place, and by the end of from eight to fifteen days the patient is well, without having to pass through a stage of convalescence and without suffering from any sequelæ.

From this summary of Werlhof's views it can be seen that writers like Du Castel and Mollière are justified in attempting to do away with the terms "morbus maculosus Werlhofii" and "purpura hæmorrhagica." As Du Castel says, "It is not a species, it is a group—I should say a medley—where the most dissimilar forms of disease *swear to find themselves in juxtaposition.*"

Purpura scorbutica shows itself first by marked constitutional symptoms. Increasing cachexia, extreme lassitude, heavy, dull pains throughout the body, with fatigue upon the least movement, are among the prodromal symptoms. The skin is dry, of a livid yellowish, earthy color. The mucous surfaces are pale, and there is frequently slight bloating of the face. In severe cases violent pains in the trunk and limbs, most intense about the knees and thorax, are experienced. The thoracic pain sometimes even interferes with respiration, the thorax feels as if encircled by a band of steel.

The first symptoms of purpura, which are apt to show themselves after eight days of prodromes, consist in the appearance of a sort of purpuric goose-flesh, hæmorrhage taking place about the hair-follicles of the lower limbs. According to Lasègue and Legroux, in their admirable report upon scurvy in Paris during the Franco-German war, the follicular petechiæ appear under the form of small roundish elevations of a deep violaceous-red color in robust patients, and of a bluish-lilac color in individuals much enfeebled by previous disease. The lesion is traversed by a hair, or rather a grayish point can be seen in its centre, made up of a little heap of dried epidermic scales under which a hair curls upon itself. On lifting this little epidermic mass with the point of a needle the imprisoned hair is released, and is then seen to be vitiated in its growth, thinned, twisted, and occasionally split at its extremity, or atrophied and deviating from its normal direction.

This goose-fleshlike purpuric eruption is caused by a sub-epidermic hæmorrhage about the hair-bulbs, and does not extend more than one or two millimetres beyond the hair which is its centre.

This form of purpura occurs by preference upon the external and anterior aspect of the leg, and next in frequency upon the same aspect of the thigh. It is also found upon the extensor surface of the forearm, rarely upon the trunk. Some single hairs of the eyebrows have been observed to be surrounded by the eruption. In the case of hairy men the eruption may at times be confluent. In women it is usually discrete. In the dirty and careless it is more marked.

The lesions appear suddenly and simultaneously; they may last from one to two months and then disappear, leaving no trace, excepting that some hairs are apt to be distorted from pressure upon their roots.

In mild cases of purpura scorbutica the petechial eruption may be the only pathognomonic sign. In many cases of scorbutic purpura, in fact in most of them, the mucous membrane also shows certain symptoms. At first, the congested gums show a blue venous band running along their free edge, of a millimetre or so in width, while the swollen interdental processes look almost like currants. In severe forms of the disease the ecchymosed gums may be greatly tumefied, even rising up so as to conceal the teeth and prevent mastication, being covered with fungous growths and bleeding on the lightest touch. The teeth are loosened and fall out, the breath is fetid, and in strumous persons the sub-maxillary lymphatic glands may become inflamed. The maxillary bones may even become necrosed. Hæmorrhagic effusions frequently take place into the mucous membrane of the mouth, particularly about the hard palate and velum, in the form either of petechiæ or of large ecchymoses. Lasègue and Legroux call attention to the important fact that the gingival changes are often wanting in scurvy, and are far from giving a highly characteristic symptom. Though this may be the case on land and in certain epidemics, yet among sailors the gums are often severely affected. Possibly the previous condition of the teeth may influence this symptom.

At a later period in the course of purpura scorbutica more or less extensive and deep-seated ecchymoses, resembling precisely the effect of ordinary contusions, are commonly observed. These are usually found upon the lower limbs and on dependent portions of the body, as the instep, calf, and popliteal region. However, in persons who use the arms in working, these limbs, or the one of these most used, may be the chief seat of the lesions. Old scars are also frequently attacked.

These ecchymoses correspond to hæmorrhagic exudations into the subcutaneous cellular tissue or the deep muscular masses. Sometimes they are large and ill-defined, more rarely they may be observed as sharply circumscribed tumors.

The larger ecchymoses may not, at first, give any sign of their presence by outward discoloration, but movements become painful and walking may be impossible. In the neighborhood of the effusion the skin is drawn, smooth, and hot to the touch. Pressure gives rise to severe pain. The muscular masses are peculiarly rigid, the limb sometimes looking as if distended by an injection of wax, which had penetrated into all the interstices. Œdema, hard and localized, may show itself, with diffuse limits; but occasionally these are sharply defined, like the groove produced by the garter in a swollen limb. The points most frequently affected are the muscular masses of the calves, the fatty areolar tissue about the tendo Achillis, the flexor tendons of the thigh, the popliteal space, and the posterior muscles of the thigh.

These infiltrations make their appearance suddenly, in the course of a few hours, and may be accompanied by slight feverishness. Walking is almost impossible, the limbs seem benumbed. Spontaneous internal pain may be experienced if the hæmorrhagic effusion occurs between a bony surface and the inextensible skin. Œdema also occurs at this stage of the disease, due to embarrassment of the circulation, and is to be distinguished from the cachectic œdema, the latter being increased whenever the patient puts foot to the ground.

When resolution, always a slow process, sets in, the skin becomes brown, soft, tense, and shining, the epidermis looks as it does when an attack of eczema is passing off, while the derma is hard, compact, woodeny, and almost incompressible. Movement gives rise to pain, the limbs are kept immovable, and the joints bathed in the infiltration become rigid. Sometimes there is a slight intra-articular effusion. As the effusion is absorbed the woodeny condition becomes more marked. When the patient first begins to walk, a fresh eruption of petechiæ shows the embarrassment of the venous circulation. The color of the skin, after passing through various shades of blue, black, green, and yellow, takes on a bronze tint, which sometimes lasts a long time.

In connection with the purpuric eruption it may be noted that abrasions, scratches, etc., are apt to result in unhealthy ulcers.

The urine in purpura scorbutica is scanty and high-colored, and yields a smaller amount of urea than normal. The albuminoids are increased, and extractive matters are also more abundant than normal, showing excessive molecular disintegration.

In severe cases of purpura hæmorrhagica, hæmorrhage from the stomach and intestine, the bladder, the nose, the hæmorrhoidal veins, etc., may occur. Gingival, nasal, intestinal, and uterine hæmorrhages are most common. In the extreme forms of the disease the cachectic œdema spreads and becomes generalized—a very unfavorable symptom. Diarrhœa succeeds constipation, serous or sero-sanguinolent effusion occurs in the larger articulations, in the visceral serous sacs, and under the detached periosteum. Scorbutic periostitis, necrosis of the maxillæ or tibiæ, separation of the epiphyses, dislocation of the callus of old fractures, and sometimes mortal syncope, may supervene. Death results from a general breaking down at all points, the intellectual functions alone remaining intact until the last.

Purpura scorbutica usually runs a rapid course. In favorable cases it may last only a week or a fortnight. Severe symptoms are not apt to supervene unless the affection has lasted for several months. Death may occur in syncope, in an attack of dyspnœa, or as a result of exhaustion from hæmorrhage. Convalescence is always prolonged, and is accompanied by extreme weakness. Fever is usually absent, but may show itself in a slight degree after considerable hæmorrhages.

Lasègue and Legroux consider two forms of scorbutus to exist: a sthenic, observed in robust persons, in which extensive hæmorrhages may occur, and an asthenic, occurring in enfeebled individuals, where there is less liability to hæmorrhage but more tendency to cachexia.

Symptomatic Purpura.—For the sake of convenience this division of purpura is made to include these cases in which the eruption is clearly a secondary symptom, occurring in the course of some well-marked disease, though it would be a difficult matter at times to draw the line between primary or idiopathic and secondary or symptomatic purpuras.

Secondary purpura occurs in the course of advanced cachexiæ or of infectious diseases, or from toxic influences. It may be simple or hæmorrhagic in character.

Cachectic purpura is observed in the course of diseases of slow evolution, as cancer, tuberculosis, diseases of the spleen, kidneys, ganglia, etc. It is not until the patient has arrived at an advanced stage of cachexia that the eruption appears. It runs its course without general malaise, without fever, and without pain. Its usual seat is upon the lower limbs, and sometimes upon the forearms, where it occurs in the form of small, slightly elevated spots, the centre of each usually being a hair-follicle. Ecchymoses of any considerable size are rare. The gums are not apparently affected. The purpuric eruption does not seem in any way to modify the course of the disease. In a few cases, particularly of acute tuberculosis, internal hæmorrhage complicates the affection, of course rendering the prognosis more grave.

Senile purpura is a form of cutaneous hæmorrhage which chiefly affects the upper extremities of elderly women whose arms are exposed to cold and to external injuries. It appears on the forearms in the form of spots

of varying size. Each spot lasts from seven to ten days, but the condition may persist for years.

Infectious purpura shows itself in the course of severe pyrexiæ or toxic conditions. It forms one of the series of symptoms in such affections as typhus, plague, yellow fever, and phosphorus-poisoning; or it may show itself on rare occasions in the severer forms of variola, scarlatina, measles, or cerebro-spinal meningitis. In the former class of cases the appearance of purpura does not materially increase the gravity of the prognosis, but in the latter forms of disease it is a symptom of great gravity, and is not infrequently the precursor of a series of severe visceral hæmorrhages (see Bulkley, Neumann, and other authors on purpura variolosa).

The cutaneous lesions are diffuse, and may occur on any or all parts of the body. They are a mixture of petechiæ and of extensive ecchymoses of a deep livid color, sub-conjunctival ecchymoses, hæmaturia, metrorrhagia, gastric and intestinal hæmorrhages, hæmoptysis, etc. The general condition is profoundly influenced; high fever with anxious respiration supervenes, and the patient rapidly succumbs with symptoms of ataxo-adynamia, or is carried off by excessive hæmorrhages. The purpuric eruption is often preceded by the appearance of diffuse exanthemata, as the scarlatiniform or rubelliform rash of variola.

Similar purpuric eruptions occur in connection with affections of the liver and spleen, such as icterus gravis and leucocythæmia.

To this class of purpuras belong those caused by the ingestion of various medicines, as iodide of potassium, salicylic acid, etc., though these purpuras are of a very much milder type, resembling purpura simplex, and not being accompanied by visceral hæmorrhages.

Mechanical purpura is observed as a result of tension in the blood-vessels, suddenly brought about by such causes as severe attacks of coughing in whooping-cough, or the convulsions of epilepsy. The purpura in this case consists in punctate hæmorrhages limited to the skin about the orbital cavity. It is rare to see generalized purpura in this variety; such an occurrence signifies an attack of extreme severity, or a marked predisposition to cutaneous hæmorrhages. Phlegmasia alba dolens, varicose veins, and certain forms of heart disease are apt to be accompanied at times by outbreaks of purpura. The significance of this form of the disease is trifling.

Mention may be made under this head of cutaneous hæmorrhages in hæmophilia (see art., Blood) following contusions or resulting from flea-bites. These last are apt to be mistaken for purpura, and a long article which appeared some years ago, from the pen of a Dublin physician, on a mysterious epidemic of purpura, was found to be based on a mistaken diagnosis in this respect.

It will be observed that purpura is produced under a very great variety of circumstances, and thus the very numerous clinical observations of the various forms of the affection have tended to overwhelm the student with a mass of facts which it is very difficult to arrange in any satisfactory system, or to approach from any common stand-point. The study of the pathology of the disease, however, throws light upon the subject, and must therefore be considered with some attention.

Changes in the Blood in Purpura.—These have been studied by a number of observers within the last few years, but the results as yet have not thrown much light upon the part played by them in the production of the purpuric extravasation. A greater or less diminution in the number of red corpuscles and in the amount of solid matters has been observed, and also inconstant variations in the amount of fibrin. In hæmorrhagic and infectious purpura the fibrin has been found to be diminished in quantity, while in purpura simplex and purpura scorbutica it has been found in increased quantity. In addition, the white corpuscles are frequently increased in number, the red corpuscles are altered in form, and bacteria and embryonal elements are present.

These facts are not of the first importance, nor do they explain the cause of the disease. It must, however, be remarked that an increase in the quantity of fibrin contained in the blood does not seem to prevent its escape from the vessels.

Lesions of the Blood-vessels in Purpura.—Fatty or amyloid degeneration of the capillaries has been accused of inducing hæmorrhages through fragility of the vascular walls, but positive observations on this subject are as yet too few in number to enable a positive statement to be made. The suggestions of atheroma of the capillaries, of thinning, softening, or porosity of the walls of the smaller vessels, of congenital or acquired fragility, are theories rather than the statement of observed facts.

B. W. Richardson describes three varieties of purpura, the aqueous, the saline, and the vascular, but these divisions are theoretical and are in some points contradicted by facts. For instance, chlorotic and hydræmic patients, whose blood is certainly watery to a typical degree, are not particularly liable to purpura.

Disturbances of Circulation in Purpura.—The study of the circulation itself in purpura should add to our knowledge of the pathology of the disease, but this has not until recently been carried out in a satisfactory manner. From recent investigations by French observers, it appears that congestion and stasis play an important part in the production of the purpuric lesion. Not only do the few microscopic examinations which have been made seem to prove this, but the fact that purpura is seen in connection with congestive rashes like those produced by medicines, the exanthemata, etc., seems to indicate the same thing.

We may consider it as probable, then, that disturbance of the capillary circulation, and augmentation of the blood-tension, are the points of departure of the purpuric spot, and that we may look for the origin of hæmorrhagic symptoms rather in blood-stasis than in an ill-understood condition of fluidity of the blood, or in a still less clearly understood vascular fragility.

As to the question how these disturbances of the capillary circulation originate, it appears that in many cases they seem to arise from some vaso-motor disturbance of innervation. The congestive patches, the œdematous eruptions, precursors of the hæmorrhagic spot in the numerously reported cases of exanthematic purpuras are indications of this perturbation.

The observations of Bouchard, who ligated the aorta after division of the cervical sympathetic, with the result of producing ecchymoses of the pinna of the ear on the corresponding side, support the view just stated. Other experimenters have succeeded in producing ecchymoses through lesions of the cord, so that experimental as well as clinical proof (Faisans, Straus, and others) can be adduced in support of this theory of the pathology of purpura.

Diagnosis of Purpura.—The diagnosis of purpura rarely offers any difficulty. The essential lesion, an extravasation of blood into the skin, is different from the lesions of all other skin affections. Pressure of the finger on the matured lesion fails to make it disappear, a condition which does not obtain in the papulo-macular syphiloderm or any other skin disease with which purpura is liable to be confounded.

Treatment.—In the treatment of purpura, attention must first be paid to the removal of the cause, if this can be ascertained. Nutritious diet, and, above all, if the hæmorrhage be extensive, rest in the horizontal position, are important. In purpura simplex, ergot, the preparations of iron, quinine, the mineral acids, together with frictions and cold baths, are beneficial. Purpura hæmorrhagica calls for prompt and decided treatment. Perfect rest in the horizontal position, with the same medical treatment as in purpura simplex, is appropriate. Oleum erigeron in five- to ten-drop doses on sugar, every two to four hours, has been highly recommended. Magee Finny says that ergot and belladonna are to be given first, and bark, ammonia, and the mineral acids later. In severe cases the ergot may be given hypodermically (one grain of ergotine repeated in four hours was thus administered by Minich successfully). Electricity has been used by Shand where other remedies have failed. In ordinary

cases, tincture of the chloride of iron, in doses of twenty to thirty drops thrice daily, alone or with digitalis and ergot, may be given. Turpentine and the acetate of lead, with opium, may also be given. Externally, sponging with vinegar, solutions of tannin, alum, etc., are often employed. Ice applied locally, and ice-water enemata when there is hæmorrhage from the bowels, may be employed with benefit.

Prognosis.—The prognosis of a case of purpura will depend much upon its nature and variety. That of purpura simplex or purpura rheumatica, exanthematica, or scorbutica, is in almost all cases eventually good, though the termination of the disease may long be delayed by successive relapses. On the other hand, infectious purpura almost always ends fatally. The prognosis of cachectic purpura varies with the cachexia, whether this is due to organic disease, to a curable affection, or to bad hygienic conditions. Those forms of purpura which occur in the course of other diseases, as the result of nervous or mechanical causes, are in most cases mere episodes in the history of the affections which they accompany. The febrile condition, when this exists, is an important element in the prognosis of purpura, rendering it more grave.

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PUTREFACTION. Animal and vegetable tissues and juices undergo certain changes after death, if kept under proper conditions of moisture and temperature. These changes, termed putrefaction, decay, or rotting, amount to a mechanical softening in the case of solid substances, a discoloration if the material be colored, and, chemically, a splitting up of complex substances into simpler combinations, with the formation of ill-smelling products. Under the term fermentation changes of a similar character are also included, and the distinction between fermentation and putrefaction is not always an absolute one. The former designation is used particularly when the resulting products are of a useful nature, and besides, in the special case of transformation of sugar into alcohol under the influence of yeast.

Decay is not due to a chemical instability of dead organic substances, as was formerly supposed. It is the result of the growth of micro-organisms, especially bacteria, in and upon the material, and if these be excluded putrefaction does not occur. In order to explain how this statement can be proven experimentally, it is necessary to premise that bacteria exist throughout the world wherever putrescible material occurs; that these bacteria, on account of their ubiquity and minute size, are carried by the atmosphere in the form of dust, and that they are hence found deposited on the surfaces of all objects in inhabited localities. Wherever material which can serve as food for these micro-organisms is exposed, they will hence gain entrance into it inevitably. In order to prove that organic material can be kept without rotting, if protected against the entrance of bacteria, it must be taken from the interior of plants or animal bodies. If glass tubes be freed from adhering living bacteria by heat, and then be thrust into succulent fruits or vegetables through a part of the surface which has been purified by the momentary contact of a flame, the unaltered juices can be collected in such tubes and kept fresh for an infinite length of time (Van der Broeck, Roberts[1]). In a similar manner animal urine or blood can be gathered and kept unaltered permanently (Pasteur). The tissues of an animal recently killed may be cut out and transferred into closed flasks previously heated, where they will remain fresh forever (Meissner,[2] Hauser[3]). These experiments, however, require the utmost precautions. All the instruments used must be previously heated, and contact with the skin of the animal and all foreign objects must be absolutely avoided. Even in that case success is not invariable, because germs of putrefaction may be deposited from atmospheric dust. But with increasing skill of the investigator the percentage of successful experiments increases. Whenever putrefaction does occur in the case of any unsuccessful experiment of this kind, bacteria can be invariably seen with the aid of the microscope, while in those instances in which the material remains fresh no living micro-organisms can be found. The methods of examining, staining, and cultivating bacteria may be found described in the article, Micro-organisms.

Equally demonstrative experiments can be made in a simpler manner by placing organic substances, without such special precautions, into clean vessels and subsequently destroying all germs which may be present by vigorous boiling (Pasteur). As long as the vessels remain properly closed their contents will stay fresh and unaltered, but on allowing the atmospheric dust to enter them, or on inoculating them intentionally with a trace of putrid material, bacteria will at once begin to develop and putrefaction sets in. Pure air is not sufficient to start the putrefactive changes. The bottles may be plugged with cotton which allows the air to penetrate, but filters out the dust, or the air may be allowed to enter through narrow and tortuous tubes (Pasteur), in which the dust is deposited and caught, without producing any change in the contents. In order to perform such experiments successfully, however, it is necessary to know that all terrestrial objects are covered with germs of which a single one is sufficient for the development of infinite numbers; and that these germs can be destroyed with certainty only by a dry heat of at least 150° C. continued for at least three hours, or by steam of the temperature of 100° C., acting at least some three minutes (and in exceptional cases even a much longer time is required for sterilization). These experiments, varied in every possible manner, have invariably proved successful in the hands of those investigators who fully appreciated the difficulties surrounding them; while their exactness and absolute

* Particular acknowledgment is due to the author of this admirable résumé of our present knowledge of purpura, upon whose work the above article is based.

correctness were denied only by authors negligent in their precautions. Since the difficulty of excluding bacteria, or of destroying them after their entrance, has been fully recognized, all opposition to their importance has ceased. It can hence be stated as a well-proven dogma, that *putrefaction consists in a chemical decomposition of organic substances due to the life and activity of micro-organisms growing upon them.* A notable feature of these changes is the large amount of material decomposed by an apparently small mass of vegetable micro-organisms.

The microscope, however, shows that the disproportion between the material decomposed and the agency decomposing it, is not so great as it seems at first, since the minute size of the individual micro-organisms is fully compensated for by their enormous number.

A clear distinction must be made between the processes of putrefaction and fermentation on the one hand, and, on the other, chemical changes produced in certain organic substances by the action of non-organized soluble chemical ferments.

Instances of the latter kind are the dissolution (and peptonization) of albuminoids by pepsine and trypsine, the transformatisn of starch into dextrine and sugars by animal or vegetable diastase, the splitting of neutral fats into free acids and glycerine by ferments of the gastric and pancreatic juices, and numerous kindred examples occurring in animals and plants. In all such instances the active agent is a complex soluble organic, but not living, substance termed a ferment, which is produced by the living animal or vegetable cells, and can be extracted from them by suitable means. While these chemical ferments can decompose an amount of material very large compared with their own mass, there is still a limit to the possible proportion between chemical ferment and decomposed material, while of living micro-organisms a single one will ultimately multiply sufficiently to attack any amount of putrescible material. The essential difference consists, therefore, in the power of increase of living ferments, which dissolved chemical ferments do not possess. Practically it is sometimes difficult, except by microscopic investigation, to distinguish between the two classes of processes, since both are similarly influenced by about the same conditions of temperature, or by the addition of favorable or injurious chemicals. The formation of chemical ferments is not limited to the cells of higher animals and plants, but occurs as well in the bodies of the lowest living forms. In some instances they are secreted also by living micro-organisms, like yeast-cells and different forms of bacteria, and are of advantage to them in their preliminary solution and digestion of the material which they decompose. However, but few of such instances are as yet known, and the assertions of some chemists, that all putrefactive changes can ultimately be traced to soluble ferments secreted by the micro-organisms, are unfounded in their generality. In the light of our present knowledge, most of the instances of putrefactive and fermentative processes must be regarded as occurring in the interior of the bodies of living micro-organisms.

Conditions of Putrefaction.—The decomposition of putrescible material proceeds at the same rate as the growth and multiplication of the bacteria causing it, and is subject to all influences affecting the latter. Bacteria require a supply of nitrogen, carbon, and mineral salts as food, and unless the soil can furnish the necessary elements they cannot grow. The nutritive substances may, however, exist in a very great dilution dissolved in water. Thus even distilled water will allow some forms of bacteria to multiply in it. But there are vast differences between different forms of micro-organisms in their ability to subsist on soils of greater or less complex chemical nature. Thus some varieties can extract their supply of nitrogen out of ammonia-salts, while others cannot dispense with albuminoids for food. Albuminoids, especially in the form of peptone, are, however, the best soil for all bacteria.

Micro-organisms require for their growth a moist soil. Thoroughly dry material does not permit the development of bacteria and cannot be attacked by them. An acid reaction of the soil is unfavorable to most bacteria. Even those varieties which produce acids by their own activity, like the lactic-acid bacilli and acetic-acid bacteria, are sensitive to their products and cannot acidify their soil beyond a certain degree. Like all higher beings, bacteria produce substances as the result of their tissue-change, which, when they accumulate, are injurious to them. In the case of the putrefaction of albuminoids, indol, scatol, and phenol (carbolic acid), substances of distinctly antiseptic properties, are among the terminal products in an amount sufficient to check further bacterial activity. Hence the growth and decomposing activity of micro-organisms cease in many instances before the soil in which they grow is completely decomposed or fully exhausted as food. This self-limitation of bacterial activity does not, however, occur in all instances.

The influence of atmospheric oxygen upon their life and activity has received most attention since Pasteur formulated his view in the striking statement, that "fermentation is life without oxygen." This generalization was founded upon his researches on alcoholic and butyric-acid fermentations, both of which can occur in the absence of all free oxygen. He divided micro-organisms into aërobes, which require oxygen like all higher beings, and anaërobes, which can exist only where free oxygen is absent, and claimed that only the latter class can act as agents of fermentation and putrefaction. Unbiassed investigations, however, by others (Hueppe,[14] Liborius[4]) have shown that Pasteur's generalization is altogether too dogmatic. There exist all gradations of susceptibility to oxygen among different bacteria. The life of some varieties depends upon the presence of free oxygen fully as much as is the case with higher beings, while at the other end of the scale are found bacteria which can grow only when free oxygen is entirely absent. But the majority of bacteria occupy an intermediate position, thriving best in the presence of oxygen, but able to continue their life and activity without it. Pasteur's statement that the fermentations proper can occur only in the absence of oxygen has not been confirmed by others. In the case of putrefaction of albuminoids it has been demonstrated that, while it may occur when free oxygen is absolutely absent, it is then a much slower process than in the presence of oxygen (Jeanneret[5]), and perhaps qualitatively somewhat different (Rosenbach).

Bacterial activity is greatest at a temperature varying from 32° to 40° C., according to the variety of bacteria. Cold retards it, and at between 5° and 10° C. it practically ceases. But extreme cold, as low as can be produced artificially, does not destroy bacteria effectually, only reducing them somewhat in numbers. On the other hand, a temperature of 56°, or at the most 60° C., maintained for at least twenty minutes, kills all bacteria during the period of growth with certainty. If in the dried state, however, they require a temperature of more than 100° C. for their destruction, while the more resistant spores of bacilli can be destroyed only by actual boiling or exposure to live steam during a period varying from three minutes to fully twenty minutes, in extreme instances. Dry heat, in order to be effectual in killing spores, must be maintained at 150° C. for at least three hours. A very reliable method, however, of destroying bacteria wherever resistant spores are present, is by means of discontinuous heating. A temperature of 58° C., or more if applicable, will suffice to kill all developed and growing bacteria, if maintained for a sufficient length of time in proportion to the quantity to be sterilized. The spores which escape uninjured will then begin to germinate, if the soil is kept at a favorable temperature, and in the germinating state they are readily destroyed by a second heating after the lapse of some hours, after which a chance may be given for the development of any spores yet dormant. A mild heating thus repeated from three to five times in the course of as many days can in this manner sterilize any material with certainty.

Exposure to the rays of the sun is unfavorable to the growth of bacteria, and it has even been found that some forms may be killed by twelve hours' insolation in midsummer (Downes and Blunt, Duclaux[6]). These experi-

ments, however, have not yet been varied sufficiently to do justice to the subject.

It has further been learned that rapid motion and agitation of fluids is unfavorable to the growth of bacteria in them (Howarth, Reinke).

Upon our knowledge of the conditions of putrefaction are based the various industrial means of preserving food. Drying the decomposable material is one of the oldest household means; for instance, in the case of fruits and thin slices of meat. In smoking meats we avail ourselves of the antiseptic properties of the creasote of the smoke; while strong brines or vinegar used in preserving articles likewise render the soil unfavorable for the growth of bacteria. Sterilization by heat is made use of in canning meats and vegetables, and the very success of this procedure, carried out on such a vast commercial scale, is but a proof of the accuracy of our knowledge concerning the causes of putrefaction.

A study of different putrefactive processes teaches that the kind of micro-organisms varies with the material and mode of decomposition observed. Each special form of decomposition is due to a specific form of bacteria. Thus the kinds which rot albuminoids are different from the kinds which sour milk or decompose urea, and most of the disease-germs so far studied are found to exert no decomposing influence at all upon the dead soil in which they are cultivated. But there exist, in all probability, a number of varieties which can decompose a given material, though the resulting products may vary quantitatively and qualitatively according to the species causing the decomposition. Thus urea may be transformed into carbonate of ammonia by at least four different kinds of bacteria, and milk-sugar can be changed into lactic acid by two forms of bacilli, and several varieties of micrococci. Indeed, a form which produces a characteristic decomposition of any certain substances need not be chemically inert in relation to other substances. A satisfactory survey of the field is, however, only possible if we take the broad view that there exist numerous varieties of bacteria separate and distinct from each other, each with a given chemical energy peculiar to it. Wherever, therefore, decomposable material is exposed, the variety or varieties of bacteria which can develop in it by reason of their adaptation to the soil, or accidental introduction in overcrowding number, will determine the chemical course of the decomposition. From this point of view we will consider, as fully as is consistent with the plan of this work, the various kinds of putrefactive processes and the biology of the micro-organisms involved.

Decomposition of Albuminoids and other Nitrogenous Tissue Materials.—Of all organic substances the complex nitrogenous materials which constitute the basis of the animal and vegetable tissue are the most readily attacked by putrefactive bacteria. When in the solid state, the albuminoids and related substances are gradually dissolved by the bacteria—probably by the aid of ferments analogous to the pancreatic ferment (trypsine) secreted by the micro-organisms. This action is illustrated by the liquefaction of gelatine and coagulated blood-serum around the colonies of many varieties of bacteria growing on such a culture-soil. The transformation which then occurs resembles chemically the digestion of these substances in the alimentary canal, at least in the earlier stages of putrefaction. Soluble albuminoids are formed, and these in turn are changed into peptones. But as fast as any new product occurs it is further attacked, so that within the first twenty-four hours of active putrefaction a large variety of decomposition products can be detected in variable proportion. As the process continues the amount of the more complex substances diminishes, and those built on a simpler chemical type augment in proportion. As the principal products gradually formed, and in their turn further decomposed, may be mentioned soluble albuminoids, peptones, leucine, sometimes tyrosine, glycocoll, volatile fatty acids, viz., butyric and valerianic (with smaller amounts of acetic) acids, indol (and in traces also scatol and phenol), while the simplest ultimate derivatives are ammonia, sulphuretted hydrogen, and carbonic acid. The offensive smell of rotting material is due to the sulphuretted hydrogen, ammonia, indol, scatol, volatile fatty acids, and presumably traces of other derivatives not yet identified. The chemistry of albuminoid putrefaction cannot be stated in any series of formulæ, since it varies qualitatively, and still more so quantitatively, with the material attacked, the presence of impurities, the temperature, and probably also the species of bacteria involved. Besides the principal products enumerated, smaller quantities of many other compounds occur temporarily in the course of any putrefaction. Of special interest among them are a series of alkaloids, which have been termed *ptomaïnes.* They have recently been studied more thoroughly by Brieger,[7] who has isolated over fifteen alkaloids from different putrid materials, some of which are intensely poisonous to animals, while others are indifferent. These ptomaïnes exist only in small quantities and transiently, being destroyed as the putrefaction proceeds. It is probable that these alkaloids or ptomaïnes are not the only poisonous substances formed by putrefactive bacteria, since at different stages of putrefaction intensely poisonous action can be obtained from extracts of the material made with glycerine and other solvents.

Numerous different forms of bacteria can be found in rotting material. The rôle played by each of the different micro-organisms in putrefaction has not yet been ascertained with certainty. There are probably several varieties of bacilli able to decompose albuminoids. A bacillus has been isolated from the human fæces which in pure culture decomposes albumen, or any of its decomposition products, in the same order as in the usual form of putrefaction (Bienstock). This bacillus is characterized by the transition through different shapes of short and long cells and filaments, and the final formation of terminal spores, giving it the appearance of a drumstick. This form is, perhaps, the most common one found in putrid material. Possibly this shape may pertain to several separate varieties of bacilli, since Hauser[9] has obtained from rotting solutions three bacilli answering to this description, but differing from each other in the rapidity with which they attack albumen. Characteristic, also, of the forms studied by Hauser is their pleomorphism, the cycle of shapes through which they pass in pure culture being made up of elliptic cells, short rods, long rods, filaments, and in some cases screw-shaped spirilla.

Several other micro-organisms have been identified by Rosenbach[10] as the agents of albuminoid putrefaction. Three of them were bacilli, of which one is probably identical with the bacillus found in fæces. A fourth form of microbe was an exceedingly small micrococcus. These bacteria, when tested in the absence of oxygen, were still capable of attacking albumen, only in a much slower and less complete manner than when oxygen was present. It is probable that micrococci and short forms of bacteria (the so-called bacterium termo), found mainly in the upper layer of decaying solutions, play a rôle in the oxidation of the various products formed.

Decomposition of Urea.—Whenever urine collects under favorable conditions of temperature it acquires in the course of some days an ammoniacal odor. This is due to the transformation of urea into bicarbonate of ammonia, by combining with two molecules of water. Although urea undergoes this change readily on boiling in alkaline solution, it will not decompose spontaneously, and urine caught in vessels free of germs retains its composition unaltered. By means of pure cultures, on dry nutritive soil, four varieties of bacteria have been found which can produce the hydration of urea (Leube and Graser[11]). Of these, one was a micrococcus forming chains, and three were different forms of short bacilli. Other bacteria, as far as they have been tested, did not exert such action upon urea. Indeed, urine when allowed to stand will invariably harbor different varieties of micro-organisms, but unless containing one of the specific species of *micrococci* or *bacilli ureæ*, it may become putrid without containing bicarbonate of ammonia.

In consequence of disease of the bladder the urine is sometimes voided already in a state of ammoniacal de-

composition. In such instances bacteria are always found in it, which have been introduced into the bladder by means of impure catheters. But from ammoniacal urine a non-organized ferment has been isolated by means of precipitation with alcohol, which in aqueous solution will gradually transform urea into ammonia carbonate without the further presence of bacteria. Whether this chemical ferment is formed in the first instance by the micro-organisms is as yet an open question, though this is the most plausible view. It could not be obtained, however, by filtering out through porous clay cells the specific bacteria artificially added to normal urine. In the older books an acid fermentation of the freshly voided urine is described. According to later researches (Roehmann [12]) this does not exist, except when the urine contains sugar or alcohol.

DECOMPOSITION OF MILK.—Milk can be obtained from the udder without the admission of micro-organisms, but only on exercising the utmost antiseptic precautions, and even in that case not every attempt is successful (Lister,[13] Cheyne, Meissner [2]). In such successful instances it will remain sweet forever, provided all future access of micro-organism is prevented. Ordinarily, however, milk sours very speedily, its milk-sugar becoming transformed into lactic acid. The curdling of the caseine, which occurs when milk sours, is due to the action of the lactic acid formed, which latter change is always the result of bacterial action. The most common agent of the souring of milk is a very short bacillus, which under a low power of the microscope might be mistaken for an elongated micrococcus, there being usually two cells adherent to each other (Hueppe [14]). This bacillus produces spores which require thorough boiling of the milk for at least thirty-five minutes before they can be destroyed with certainty. Milk-sugar (as well as other varieties of sugar) are split by it into lactic acid and carbonic acid. The lactic acid stops further bacterial action after accumulating to the extent of about 0.8 per cent. In order to obtain lactic acid in quantity, it is therefore necessary to remove the acidity by means of carbonate of calcium. The bacillus just described can act only in the presence of oxygen. But another micro-organism, apparently identical with this one in shape, growth, and action, which has been found in the fæces of nursing infants (Escherich [15]), does possess the ability to acidify milk-sugar even in the absence of oxygen. Possibly this may be but a physiological variety of the first-described bacillus. Another bacillus, not yet sufficiently described, which has been cultivated from the fæces of adults (Bienstock [8]), decomposes milk-sugar into lactic acid and alcohol. Milk can also be soured by the various micrococci found in pus, as well as by the micro-organisms of erysipelas and pneumonia.

Lactic acid is transformed into *butyric acid* by certain forms of very large bacilli. They cannot, however, attack the original milk-sugar unaided by the lactic-acid bacteria. Their spores are killed with some difficulty in milk, so that, when a number of samples are sterilized by boiling, it sometimes happens that the butyric-acid bacilli escape destruction. In such cases the milk curdles subsequently without souring, because these bacilli secrete a ferment of similar action to rennet, which coagulates the caseine. The curdled caseine is later redissolved by the same bacilli, and changed into peptone with the formation of some bitter product (Hueppe). The bacilli can transform lactic acid and lactates (as well as some other organic salts) into butyric-acid, with the liberation of small quantities of butyl alcohol (Fitz [16]). The flavor of matured cheeses and milk beverages, like koumiss and kephir, is the result of their action.

The butyric-acid bacilli have been separated into three varieties, distinct from each other, by cultivation on dry soil in a vacuum (Gruber [17]). Of these varieties two are strictly anaërobic, and cannot act except in the absence of oxygen; while the third form, though able to dispense with oxygen, thrives best when supplied with it.

Cellulose can be dissolved and decomposed by a large bacillus found in the mud of swamps, and also by an undescribed micro-organism occurring in the intestines of cattle. It is split into carbonic acid and carburetted hydrogen (CH_4), or, in alkaline solutions, into carbonic acid and free hydrogen. It is probable that the disappearance of the ingested cellulose in the digestive tract of herbivora is entirely the work of micro-organisms (Tappeiner [18]).

The turning rancid of fats, whereby they are partly decomposed into free fatty acid and glycerine—which latter undergoes further change into ill-smelling products, yet insufficiently examined—is not the result of bacterial action. Although this process resembles putrefaction in the conditions by which it is influenced, no characteristic bacteria could be recognized by the microscope or culture methods in some unpublished experiments made by the writer with Mr. Hoskins. It was likewise found impossible to hasten the rancidity of fresh fats by infection with rancid samples. Duclaux [19] has since arrived at similar results, and has referred this change to oxidation.

The *alcoholic fermentation* is ordinarily produced by yeast-cells, although some bacteria have been found which can likewise form alcohol (Bienstock [8], Fitz [16]). Whenever this fermentation occurs at a high temperature, as in the distilleries, it is complicated by the presence of different forms of bacteria—lactic- and butyric-acid bacilli and others—which interfere with the work of the yeast quantitatively, besides producing products of their own which give an unpleasant flavor to the spirits. In observations made in a distillery by the writer, with the late Mr. Woltmann, it was found feasible to increase the yield of alcohol and improve the flavor of the product by employing pure cultures of yeast, and excluding bacteria as far as possible.

The acetic acid fermentation of alcohol is due to a micro-organism growing in the form of chains, which has not been studied morphologically to a sufficient extent, and of which it is uncertain whether it is a large micrococcus or a short bacillus. It oxidizes the alcohol into vinegar, and hence requires free access of oxygen for its action (Pasteur).

Hygienic Aspects of Putrefaction.—Medical interest is deeply concerned in all putrefactive processes, in relation both to the biology of the micro-organisms and to the chemical or poisonous properties of their products. Some of our articles of diet are consumed in a state of partial decomposition. For instance, most cheeses have passed through a lactic- and butyric-acid fermentation, while in some favorite brands actual putrefaction has occurred, as the smell plainly indicates. The gamy flavor, or "haut goût" of meat, demanded by epicures, proves its commencing decomposition, while in many other instances it is placed on the table strongly tainted in the warm season, not intentionally, but from want of care in its preservation. But no harm results ordinarily from the use of such articles. Instances, however, do occur where families, or even communities, are poisoned by the consumption of cheese or meats, especially fish and sausages. The symptoms are those of intestinal irritation, vomiting, nausea, diarrhœa; furthermore, prostration and generally marked dryness of the throat. It is yet an open question whether the articles causing such wholesale poisoning must be eaten while in a particular stage of putrefaction, or whether their decomposition in such cases is due to some specific form of bacteria different from the ordinary agents of putrefaction, and capable of forming poisonous products peculiar to themselves.

The latter view is the more probable one, since in such instances of poisoning the food does not generally indicate decomposition by its smell and appearance. The rapid onset of the poisoning, and its short duration in cases of recovery, suggest that it can only be the effect of a chemical poison, and not an infection due to the entrance of bacteria into the system, at least in most of the instances reported. In a case of sausage-poisoning Ehrenberg [20] found the usual decomposition derivatives of albumen, including some of the less poisonous ptomaïnes, but still he could not detect the special poison to which the observed effects were to be attributed. He isolated a bacillus from the sausage, capable of decomposing albu-

men, but our information is not precise enough to say whether this was one of the common forms of putrefactive bacteria or not. In an instance of poisoning from dried beef (in Momence, Ill.) the writer found in different samples of the meat, alternately, a micrococcus and a short bacillus present in large numbers, which differed morphologically from the organisms found in ordinary putrid material. The meat did not appear tainted. From cheese which had poisoned a large number of persons, and later on, also, from poisonous ice-cream, Vaughan[21] has isolated a substance which he terms tyrotoxicon, and which possesses the characteristic poisonous action as tested upon man. He is inclined to consider this substance identical with diazobenzol.

On considering the hygienic relation of putrefaction, it must not be forgotten that this process occurs normally in the intestines below the stomach. In the mouth of all individuals there exist a very large number of micro-organisms, many of which are capable of causing putrefactive and fermentative changes in food (Miller[22]). While the conditions in the mouth permit them to multiply to some extent, they find no material to attack except in hollow teeth, or between the teeth and receding gums, and in such cases their action reveals itself in the tainted breath. It can hardly be expected that these parasites are always harmless, although we do not yet know fully their etiological significance.

The hydrochloric acid of the gastric juice has sufficient antiseptic power to kill all developed bacteria, if present to the extent of over 0.16 per cent., but it cannot injure spores. Hydrochloric acid, however, does not occur in an empty stomach, is not secreted within the first few minutes of digestion, and does not reach the necessary limit of 0.16 per cent. until about half an hour after meals, so that there is plenty of opportunity for bacteria to pass through the stomach alive. Moreover, particles of food shelter them somewhat even during digestion (Miller). Below the point of entrance of the bile and pancreatic juice into the duodenum, bacteria find the suitable alkaline or, at least, very faintly acid reaction, and here their work begins. Chemically, their activity reveals itself in the production of substances which cannot be formed by the action of the digestive ferments in the absence of bacteria—like indol, scatol, phenol, sulphuretted hydrogen, and the volatile fatty acids. Normal human fæces consist microscopically of scarcely anything but bacteria, except when a vegetable diet adds its undissolved residue. It is not known whether the normal intestinal bacteria are of any real service in digestion, but their invariable presence indicates that they are harmless to the individual under ordinary circumstances. But whether poisonous decomposition-products may not be formed and absorbed under some conditions—in intestinal obstruction—is an open question. It has been found that among the human intestinal parasites there occur some forms (Bienstock, Brieger[23]) pathogenic to small rodents.

The occurrence of putrefactive processes in surgical practice was the first incentive to Lister in his earliest attempts at antiseptic surgery. At that time (1867) it had not yet been proved that the traumatic infectious diseases were due to parasites, but it was evident in surgical practice that the decomposition of pus and other secretions exerted an injurious influence upon wounds. It has since been demonstrated, step by step, by the injection of putrid material into the bodies of animals, by Weber, Billroth, Panum, and others, by the bacteriological examination of Rosenbach on patients, and especially by the magnificent results of improved antiseptic surgery, that the systemic complications of wounds, ranging from the milder forms of traumatic fever to fatal septicæmic blood-poisoning, are the result of the absorption of decomposition-products of bacteria. A broad distinction must be recognized between actual surgical infection, where parasitic micro-organisms are growing in the tissues—as, for instance, in erysipelas and pyæmia (metastatic abscesses)—and putrid poisoning, in which the bacteria exist only outside of the tissues, in the fluids or necrotic parts of the wound, from which regions their chemical products are absorbed. The bacteria which can, in the latter case, poison the system may be the common forms of putrefaction, which do not possess the power of penetrating into the tissues. Quite often, abscesses with foul-smelling contents harbor putrefactive bacilli, together with the specific micrococci causing the suppuration. It is evident that those instances of septicæmia in which the cause is outside of the body offer an entirely different prognosis from actual infections, in which the surgeon's knife and antiseptic drugs cannot follow the bacteria into the tissues.

Rotting material accumulating around dwellings, the refuse of the kitchen, and the contents of cesspools have always been regarded with anxiety by sanitarians. It is doubtful, however, whether any poisonous products existing there can in any way affect us. The foul gases —ammonia and sulphuretted hydrogen—though known to be poisonous, are not generated in sufficient amounts under ordinary circumstances to cause acute poisoning, while chronic poisoning from these gases has not yet been observed or, at least, recognized. The more serious aspect of such collecting filth is the possibility of its harboring pathogenic bacteria, for the organic material which forms a nutritive soil for putrefactive bacteria may also serve as food for occasional parasitic and pathogenic forms which find their way into it. It is probable that in this way, and only thus, filth plays a rôle in the spread of some infectious diseases—for instance, typhoid fever and cholera.

Putrefactive processes play a rôle in the household of nature, and particularly in relation to agriculture, the magnitude of which has only been suspected lately. The surface soil, wherever it contains organic remnants and is suitably moist and warm, teems with bacterial life. Over half a million of germs (in an extreme case up to forty-five millions) have been found in a gramme of different soils. At a distance of several feet from the surface the vegetation of micro-organisms ceases ordinarily (Koch), though in some instances of contaminated soils they have been found as low as eighteen feet below ground (Beumer[24]). As far as the bacteria penetrate into the soil, they alter its chemical composition continuously during the warm season.

Two classes of processes occur in the ground : on the one hand, the ordinary putrefaction of organic remnants, resulting in their decomposition, and, on the other hand, a slow oxidation of organic substances. The latter change can be measured by means of the carbonic acid evolved (Wollny[25]). A study of the conditions influencing this oxidation shows it to be due to bacterial action, although the forms causing it have not been identified. This oxidizing process plays undoubtedly a considerable rôle in the removal of organic remnants from the surface of the earth, since none of the characteristic smells of putrefaction is noticeable in fields and forests, at least outside of marshy parts, although the residue of the last season's vegetation disappears annually. It is not exaggerating the importance of these processes to assert that it is only through their instrumentality that plant life is possible on the surface of the earth ; for higher plants are not able to assimilate nitrogen from the soil except it be present in the form of very simple compounds—ammoniacal salts and nitrates. It is only through the activity of the bacteria that the residue of previous vegetation or of animal bodies can serve as food for subsequent vegetation.

Historical Bibliography.—Putrefaction was a favorite theme with the older medical and chemical writers, but was discussed by them only in a speculative manner. In 1837 it was first shown, by Schwann, that putrefaction and fermentation were due to the action of micro-organisms, and this view was later on confirmed by Schroeder and Dusch. To Pasteur's ingenuity, however, we owe most of our positive knowledge concerning the actual conditions of these processes, and this brilliant investigator has shown a rare perseverance in his studies of that subject. Passing from alcoholic fermentation to putrefaction, he took up in turn lactic- and butyric-acid fermentation, and the various changes which caused the

spoiling of wine and beer. His results, published in the *Annales de Chimie et Physique*, 1860 and 1862, and also in various proceedings of the French Academy of Sciences (Comptes Rendus), are collected to some extent in his separate work, "Etude sur la Bière," 1876 (English edition by Faulkner & Robb, "Studies on Fermentation," 1879). The history of the earlier studies on putrefaction can be found in Watson Cheyne's "Antiseptic Surgery," 1882, and in Gradle's "Bacteria, and Germ Theory of Disease," 1883.

Further studies in the biology of putrefactive bacteria have been published by Bienstock[8] and Hauser.[9] But we still lack any complete classification of the different forms of micro-organisms concerned in these processes. The decomposition of milk has been thoroughly investigated by Hueppe.[14] The chemical side of putrefaction has been most advanced by the labors of Nencki ("Ueber die Zersetzungen d. Gelatine u. d. Eiweiss bei der Fäulniss mit Pancreas," Bern, 1876), while the most painstaking work has been bestowed by Brieger[7] on the separation and identification of the alkaloidal ptomaïnes.

The sanitary, and especially the pathological, aspects of putrefaction have been fully discussed, up to 1879, by Hiller, in his "Lehre von der Fäulniss." The most complete compilation of the bacteriological side of the subject can be found in Fluegge's "Fermente und Microparasiten" ("Ziemssen's Handbuch der Hygiene," 1st ed., 1883, and 2d ed., 1887). *H. Gradle.*

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[24] Beumer: Deutsche med. Wochenschrift, 1886.
[25] Wollny: Centralblatt f. Bacteriologie, vol. i., Nos. 5, 15, 16.

PYLORUS, RESECTION OF; PYLORECTOMY. The operation for the removal of the diseased (usually cancerous) pylorus is the legitimate outcome, on the one hand, of the recent progress of surgery as based on physiological and pathological studies, and, on the other, of an increasing boldness—begotten of success—in operative attacks upon the digestive tube. Among these latter we may mention gastrotomy, gastrostomy, and resection of varying lengths of the pharynx, œsophagus, and intestine. In fact, scarcely any portion of the alimentary tract has been exempt from the surgeon's knife. Twenty years ago, indeed, Torelli excised a considerable portion of the stomach-wall, which, with two penetrating wounds within its limits, had prolapsed from an incised abdominal wound; his patient recovered and lived for many years. This was possibly the first stomach-resection, though not a resection of the pylorus.

Induced thereto by previous surgical exploits, several workers began experimenting upon animals. Merrem, in 1870; Gussenbauer and Winiwarter, in 1876; and Czerny, in 1878, had made it clear that a partial, even an *entire*, resection of the stomach could be made upon dogs, and with success. All this having been demonstrated, it needed only a surgeon with sufficient boldness, and a willing patient, for a practical test of the feasibility of the operation in the human subject. In 1877, Billroth asserted that there was no reason why the operation should not succeed; in 1879 he went further, and said that it *must* succeed; but it was reserved for Péan, of Paris, to make the first essay. In April, 1879, he yielded to a positive demand for relief on the part of a patient with cancer of the pylorus. This patient died five days later of inanition, after two blood-transfusions. In November of 1880, Rydygier, of Kulm, made the second operation, his patient dying twelve days later of collapse.

Three months later Billroth reported a third case, the first successful one. His patient made a brilliant recovery, but died at the end of four months in consequence of a return of the disease.

INDICATIONS.—We may hold that resection of the pylorus is indicated in:

1. Irritable and intractable pyloric ulcer, leading to spasmodic stenosis.
2. Simple fibrous or cicatricial stenosis.
3. Circumscribed cancer, without adhesions to the pancreas or spleen.

By a legitimate extension of our limited subject we may further say that resection, either of the pylorus or of any other part of the stomach, would be indicated in:

4. Hæmorrhage from ordinary gastric ulcers, by which life was threatened.
5. Perforation of a gastric ulcer.
6. Gunshot or stab wound, if ragged or irregular.
7. Hernia of the stomach complicated with any of the above conditions.

1 and 2. Ordinarily, ulceration of the stomach does not become so aggravated as to call for operative interference, but when the symptoms dependent thereon pass endurance, or when, the active process having subsided, the lesions are succeeded by stenosis, so that the patient must be fed by enema or starve, then drugs can give no relief. It is in cases of this class, though few in number, that the operation has been brilliantly successful, five patients out of eight having been cured. In cases included under the second indication, the resection-method, to be sure, has now to compete with Loretta's method by digital divulsion; of the former it may be said that even if it be the more dangerous (though not much more so) it is the more effective.

3. It is in cases of cancer that this operation has been most frequently resorted to. It is worthy of especial note that the pylorus is by far the most common seat of cancerous disease of the stomach. Gussenbauer and Winiwarter investigated the records of the Vienna Pathological Institute, embracing a period of fifty-six years. Out of 61,287 autopsies, cancer of the stomach was found 903 times. In 542 of these the disease involved the pylorus. In 223 of the 542 cases no metastatic deposits could be found, and in 172 of them the tumor was found to be non-adherent, *i.e.*, in a condition most favorable for operation. Moreover, Rokitansky's observation, that cancer of the pylorus rarely involves the duodenum, is worth remembering in this connection.

Obviously the matter of diagnosis is one of prime importance. It is not merely the question of malignancy that is to be decided, but also that of the extent of the disease and of adhesions to the neighboring viscera. An uncomplicated case is one favorable for operation; on the other hand, involvement of the peritoneum, liver, or mesenteric glands, and firm adhesions to the colon or pancreas, make it most unadvisable. The experiments of Rydygier and Senn have shown that a piece of the pancreas may be removed with success, provided its duct be not occluded; but the difficulty of effecting this in a living patient would deter most men from the attempt. It is true, also, that a portion of the mesentery or of the colon may be excised, but the operation is thereby the more prolonged and complicated. For the symptoms and diagnosis we must refer the reader to the appropriate heading (see Stomach, Organic Diseases of). To illustrate the difficulty of diagnosis in these cases, the writer would adduce the case in which Billroth and Bamberger having

both diagnosed cancer of the pylorus, the former operated and found an anomaly of the kidney.

At all events, there can be no objection, in a case of proposed pylorectomy, to perform a diagnostitial laparotomy, limiting the operation to this in case the conditions thereby revealed make it improper to proceed. This has been done a number of times without giving occasion for regret.

4 and 5. These indications are theoretical rather than founded on experience; yet a moment's reflection will show that they are not chimerical.

6 and 7. That these indications are of practical bearing the case of Torelli, quoted above, and various recent experiences and studies fully demonstrate.

Preparation for Operation.—The absence of any very unfavorable symptoms having led to a determination to operate, the patient should be carefully prepared for th · ordeal. To this end the diet,

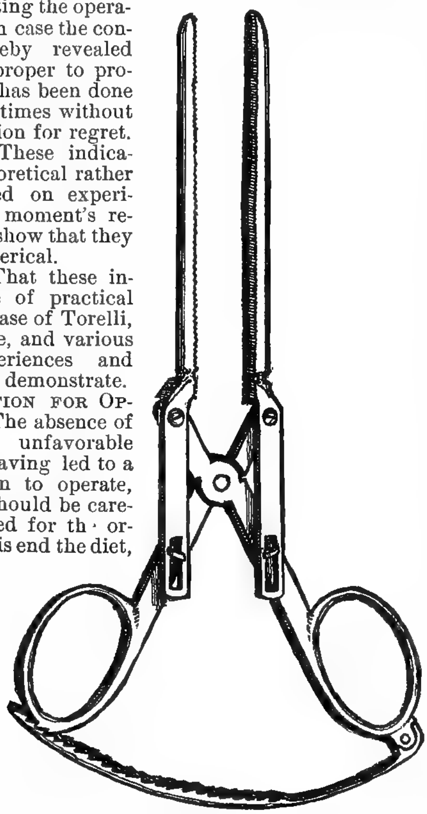

Fig. 3215.—Rydygier's Clamp, with Parallel Blades. The blades are covered with rubber tubing.

doubtless already restricted, must be simplified or reduced to milk only. The stomach should be washed out daily once or oftener, and in case the gastric symptoms have been very distressing the better way would be to feed by nutritive enemata and to frequently cleanse the stomach. Careful attention must also be given to the bowels, and, in fact, no precaution which careful laparotomists adopt should be omitted.

Operation.—Hitherto an anæsthetic has always been administered, preferably chloroform. This should be preceded by a full

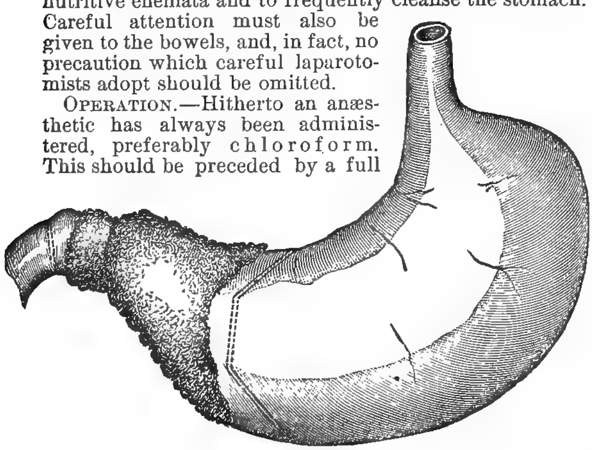

Fig. 3216.—Cancer of Pylorus. Lines indicating shape of exsected portion.

hypodermic dose of morphine. The stomach should always be washed out with a weak salicylic solution, as a preliminary to the operation, either before or just after the anæsthetic. A recent experience which the writer has enjoyed leads him to think that, after inducing a mild morphine-narcosis, cocaine used hypodermically and locally might suffice. Working thus with cocaine alone, he has been able to make a successful gastrostomy without anything more than some slight local discomfort.

By some operators the incision in the linea alba has been preferred; some have made it parallel to the left costal cartilages, others parallel to those on

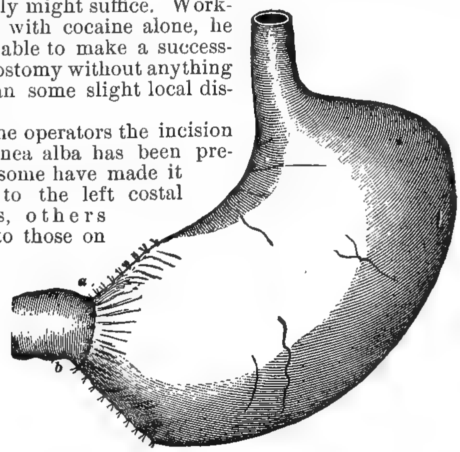

Fig. 3217.—Cancer of Pylorus. Same case as above, showing lines of suture.

the right side. An opening by which one or both recti may be severed has its obvious disadvantages, while for some of the cases the median incision would not give sufficient room. The best rule is to let the exact location and size of the internal tumor determine where and in what direction to cut.

The tumor having been cut

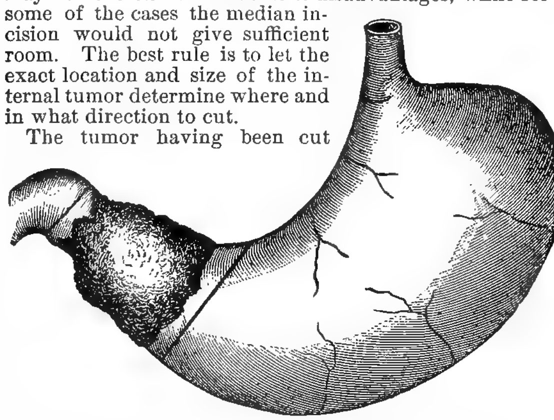

Fig. 3218.—Cancer of Pylorus. Showing portion to be removed.

down upon and exposed, as are other abdominal tumors, the surgeon must first convince himself that no contra-indications exist, especially in the way of secondary affection of the pancreas, liver, gall-bladder, or inaccessible mesenteric glands. Being satisfied in these respects, he should then draw the tumor as far forward as is judicious, and begin the task of separating it from its surroundings. These are

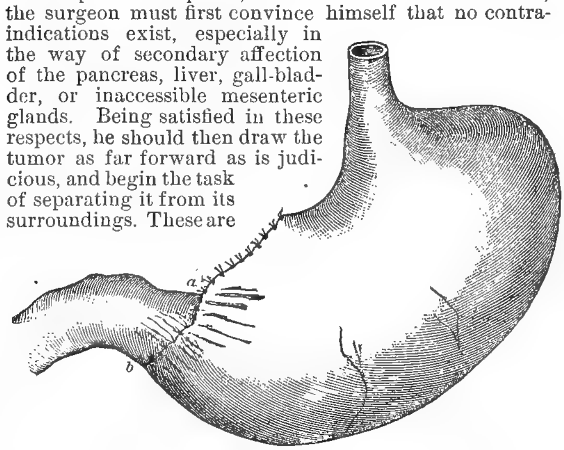

Fig. 3219.—Cancer of Pylorus. Same case as that represented in Fig. 3218. Showing lines of suture.

particularly the gastro-colic ligament and the lesser omentum. These must be separated from the pyloric region for a sufficient distance to permit the removal of the dis-

eased mass, and no farther. This is effected by including small portions between double ligatures and then dividing with the thermo-cautery. This part of the operation must be done with great care. A large sponge

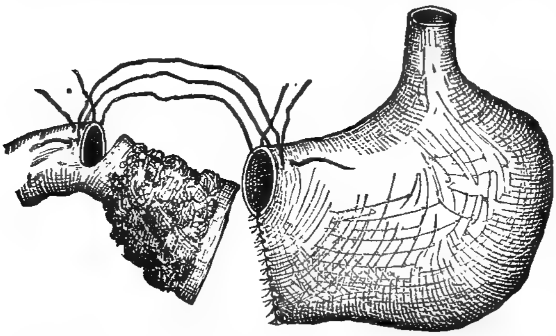

FIG. 3220.—Illustrating Technique. Placing a few retaining sutures before complete exsection.

is now passed under the tumor-mass, to isolate it from the rest of the abdominal contents. A couple of clamped forceps, or their equivalents, are lightly passed on either side of the tumor, to prevent regurgitation of gastric or intestinal contents; or, instead of these, the fingers of an intelligent assistant can be made to do the work as well or better.

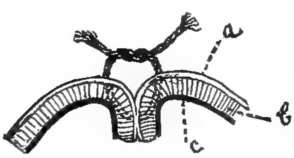

FIG. 3221.—Lembert's Suture. *a, b, c,* Peritoneal, muscular, and mucous coats.

The excision of the cancerous mass is now to be undertaken. The lines of incision must be made according to the size and relations of the tumor. The accompanying cuts (Figs. 3216, 3218, and 3220), from Woelfler's monograph, show what portions were removed from three of Billroth's cases. In other cases the exact shape of the excised portion has been different. The endeavor should be to hold the stomach completely flat, so that pieces of exactly the same shape may be removed from its posterior as from its anterior wall. Numerous small vessels in the gastric and duodenal walls will be found to bleed freely. Upon as many as require it ligatures of catgut may be placed. Hæmorrhage having been quieted, the operator at once addresses himself to the union of the divided parts.

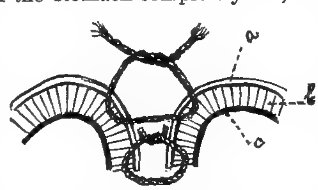

FIG. 3222.—Czerny's Suture. *a, b, c,* Peritoneal, muscular, and mucous coats.

The question now comes up concerning the best of the several intestinal sutures that have been devised. The inherent differences between the commoner and more preferable varieties can be better recognized by reference to Figs. 3221, 3222, 3223, 3224, than by verbal description. Lembert's suture takes in both the serous and the muscular coats. Czerny improved this by an additional separate stitch through the mucosa. Gussenbauer still further improved it by combining the two stitches in one act, and it is his method which we recommend. Special care must be given to coaptation, and in certain cases it may be well to place some of the stitches before the mass is completely excised, as is shown in Fig. 3220. Above all, too much caution cannot be exercised in closing the angles marked *a* and *b* in the cuts, Figs. 3217 and 3219. Should there be a doubt as to the security of the closure, it would be better to run another series of fine sutures partially or completely around.

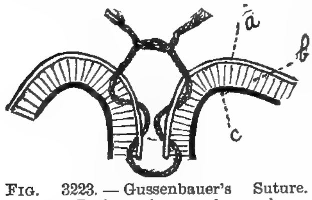

FIG. 3223. — Gussenbauer's Suture. *a, b, c,* Peritoneal, muscular, and mucous coats.

Something must be said concerning the choice of needles and suture-materials. The former must be round in transverse outline—*i.e.*, without cutting edges—small and straight, barely large enough to hold fine silk or catgut. For suture-material we recommend Chinese silk which has been carefully disinfected. It is much stronger than catgut of the same size, and is not so soon absorbed. Fine catgut may answer well for the ligatures, but silk is certainly preferable for the sutures.

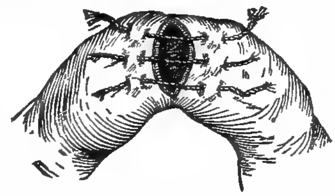

FIG. 3224.—Lembert's Suture. Applied to a small wound.

The tedious process of inserting all the necessary sutures having been completed, the clamps are removed, any toilette of the peritoneum that may be called for is made, the parts are dropped back, and the abdominal wound is closed *secundum artem.* To briefly describe the operation does not take long, but to properly perform it may consume from one and a half to three hours. It calls as much for extreme patience on the part of the operator as for skill in technique.

The patient is now to be treated as after any abdominal section, save that nothing but cracked ice, in minimum quantity, must be allowed in the mouth for from forty-eight to seventy-two hours. After this, feeding by the mouth may be attempted with scrupulous care. For the first few days feeding must be done mainly by the rectum. Every effort to prevent vomiting must be practised.

RESULTS.—While referring the interested reader to the special literature for detailed statistics of cases, we may say here that of seventy cases now on record, pylorectomy has been done sixty-two times for cancer, with thirty-five deaths (57%), and eight times for stenosis, with three deaths (37.5%). Considering that every one of these cases had that about it which made it inherently fatal, the operation seems to have been sufficiently successful to justify its performance in select cases. *Roswell Park.*

PYRMONT is situated in the principality of Waldeck-Pyrmont, in Germany, at an elevation of about four hundred feet above sea-level. There are a number of iron and saline medicinal springs in the place, the best known of which are the Stahlquelle, Brodelbrunnen, and Helenenquelle among the iron springs, and the Salztrinkquelle, Badequelle, and Bohrlochsoole among the saline.

The following are the analyses of these three iron springs, expressed in grammes per litre. One litre contains:

	Stahl-quelle.	Brodel-brunnen.	Helenen-quelle.
Bicarbonate of iron	0.077	0.036	0.074
Bicarbonate of manganese	0.006	0.003	0.007
Bicarbonate of calcium	1.046	1.003	1.246
Bicarbonate of magnesium	0.080	0.076	0.012
Chloride of sodium	0.158	0.174	0.181
Sulphate of sodium	0.041	0.036	0.043
Sulphate of potassium	0.016	0.015	0.016
Sulphate of magnesium	0.453	0.492	0.604
Sulphate of calcium	0.792	0.980	0.866
Organic matter, etc	0.044	0.043	0.052
Total solids	2.713	2.858	3.101

There is considerable free carbonic-acid gas in the waters of all these springs. Of the salt springs but one is used for drinking purposes. The analysis of this, the Salztrinkquelle, is as follows: One litre contains, of

	Gms.
Chloride of sodium	7.057
Chloride of lithium	0.006
Sulphate of sodium	0.120
Sulphate of magnesium	0.969
Sulphate of calcium	0.805
Bicarbonate of calcium	1.688
Bicarbonate of magnesium	0.024
Organic matter, etc	0.031
Total solids	10.700

The amount of free carbonic-acid gas is less than is found in the chalybeate springs.

The other saline waters are not drunk, but are used for bathing. A course of treatment at Pyrmont is especially useful in those cases in which both chalybeate and saline waters are indicated, such as various scrofulous and nervous affections, diseases of the female sexual organs, catarrhal conditions, and diseases of the digestive organs, combined with anæmia and debility.

The season at Pyrmont is from the middle of May to the middle of October. In addition to the use of the waters, there are facilities for the various forms of "cures," goat's-milk, whey, pine-needle, etc., so popular at many of the German spas. *T. L. S.*

PYROGALLIC ACID. "Pyrogallic acid" is the name in common use for the phenol *pyrogallol*, $C_6H_3(OH)_3$. This body is producible by the action of heat on gallic acid, whence the name "pyrogallic acid." Pyrogallic acid presents itself in long, flattened prisms; colorless; bitter to taste; soluble in two and a half parts of water, in alcohol, and in ether. In solution, exposed, the acid oxidizes, turning brown. Pyrogallic acid possesses the poisonous property, more or less common to the group of phenols, of affecting the blood and bringing about hæmoglobinuria. Administered by injection to rabbits, this medicine has speedily caused chill, dyspnœa, tremor of the extremities coming on in paroxysms, and death. The urine in such cases has shown the characteristic features of hæmoglobinuria, and the blood has exhibited discoloration and destruction of the red blood-corpuscles. In rapidly produced death by large doses, the blood has turned black or, in some cases, of a chocolate color and jelly-like consistence. In the human subject death has resulted, in one instance, from the application, to one-half the body at once, of a ten per cent. pyrogallic-acid ointment. In this case a violent chill, with vomiting and collapse, set in six hours after making the application of the salve. The patient rallied, but forty hours later a second attack ensued, ending in coma, with great reduction of temperature. Death occurred on the fourth day. During the illness the urine was much diminished in quantity, and showed, in highest degree, the condition of hæmoglobinuria, being dark-brown in color and, upon standing, depositing a thick sediment of amorphous, blackish material. The blood was found, post mortem, disintegrated, and the kidneys bluish-black and stuffed with the same material as the urinary sediment. Pyrogallic acid has been used in medicine almost exclusively as a local application for the relief of certain skin diseases, notably *psoriasis*—an application often successful when other remedies may have failed. Applied in solution or in ointment, pyrogallic acid stains the skin somewhat, but the stain speedily disappears. Linen clothing, however, may be permanently injured by the action of the medicine. To avoid this latter effect, a solution of pyrogallic acid in flexible collodion has been proposed (Elliot). Such preparation, when dried to a film upon the skin, seems still to exert the therapeutic action of the medicine, but, being dried, is without action upon the clothing. Pyrogallic acid may be applied in ointment or in solution, and strengths are used ranging from five to fifteen per cent. of the remedy. The higher percentages, in ointment certainly, may irritate severely, and should be used with caution. Applications should never be extensive at any one sitting, for fear of enough absorption occurring to bring about constitutional poisoning. *Edward Curtis.*

QUARANTINE. The ancients during periods of epidemic pestilence sacrificed to their gods or consulted the oracles on the best means of appeasing the offended deities, and in Christian times fasting and prayer have been undertaken as a means of preservation from these "visitations of Providence." But so long ago as the time of Hippocrates more appreciative views of the origin of epidemics were entertained, for that enlightened authority combated pestilence in Athens and other Grecian towns by directing the citizens to keep great fires burning in the streets, and feed them with herbs and drugs of sweet odor. This implied a recognition of that subtile atmospheric cause which even now exists in many lay and some professional minds, finding expression in the phrase *epidemic constitution.* The doctrine of contagion in relation to these diseases appears to have been developed slowly and almost insensibly, for although Livy speaks of the Roman citizens shutting themselves up in their houses and paying attention to nothing except how to preserve themselves from the pestilence, the time of Boccaccio was reached before systematic efforts were made to exclude contagion from a community. The epidemic which the former describes, devastated Rome B.C. 459, destroying most of the slaves, half of the citizens, many senators, tribunes, and priests, and two successive consuls. The latter refers in his tales to the attempt made by Florence to preserve her citizens from the plague which overspread Europe in 1348, by denying access to all sick persons.

When contagion was recognized in these epidemics—and probably most of them were, from the stand-point of to-day, either directly or indirectly infectious—a grand advance in preservative methods became possible. All European nations enforced laws for limiting the spread of leprosy, and these, which had been handed down from ancient times, had merely to be modified in their application in order to exercise a controlling influence on the spread of fulminant febrile diseases. The sanitary laws of Moses provided for the segregation of lepers and the fumigation and destruction of infected clothing. Among the Gentile nations these unfortunates were also ostracized; they gathered in small communities in the outskirts of cities, and ultimately hospitals were built for them. Even at the present day the spread of leprosy is controlled in the same way. In the Sandwich Islands, where two per cent. of the population is affected, the isolation of the disease to special settlements has been enforced since 1865, for contagion is acknowledged, and every leper, whether in the advanced or incipient stage, is looked upon as a dangerous focus of the malady.

When, therefore, contagion was appreciated as a factor in the propagation of wide-spread pestilential epidemics, the attempt to exclude it, as at Florence, naturally followed. Sanitary cordons were drawn around healthy places to preserve them, and around infected places to prevent the spread of their pestilence. Infected persons were taken out of the city into the fields, there to die or recover, and their attendants were forbidden to associate with anyone for ten days. Ultimately it became recognized that these epidemic diseases had their origin in the East—in Asia, Turkey, or Egypt—and entered Europe by the Mediterranean seaports. Hence, in periods of freedom from pestilence, restrictive measures were concentrated at these ports to prevent its introduction. Venice at that time was the commercial metropolis of the world. Her vessels brought the products of the East to the Western nations, and among them, occasionally, the plague. A lazaretto was built for the isolation and treatment of infected sailors as early as 1423, but not until about 1484 were laws enacted requiring every vessel from suspected localities to undergo a period of detention and observation prior to the admission of her crew, passengers, or cargo. As this period embraced forty days, the term *quarantine* came to be applied to it and all matters pertaining to it. Lazarettos and quarantine codes were afterward established at other exposed seaports, as at Malta, Ancona, Messina, Leghorn, Genoa, Trieste, Marseilles, etc. As the accommodation for suspects was generally insufficient at these quarantine stations, much hardship was inflicted during the period of probation. The full operation of the system was required only occasionally, in times of emergency, and as it was rarely equal to the occasion, extemporizations were necessitated; but these did little to mitigate the evils of the enforced detention of healthy persons in dangerous proximity to those who were infected. Thus quarantine, to its victims, appeared imbued with a spirit of inhumanity, cruelty, and reckless tyranny; and although its methods at the present time are wholly changed, much of the barbarism

of former years continues associated with the use of the term.

Unfortunately the seaport quarantines, no matter how rigorously enforced, frequently failed in their efforts to exclude the plague and prevent its spread into the interior. In this event, sanitary cordons became the established method of limiting the progress of the pestilence—they constituted, in fact, a species of inland quarantine; and, even at the present day, the panic occasioned by an extended prevalence of a deadly epidemic not infrequently calls into existence a vigorous but unnecessary policy of non-intercourse, known in Europe as the *cordon militaire*, and in this country as the *shot-gun* quarantine.

Improvements in the sanitary condition of Europe, consequent on the progress of modern civilization, have succeeded in preventing those terrible visitations of the plague against which quarantine was first instituted. London has not suffered since 1665, and although certain sections specially exposed to infection from the East, as Egypt, Turkey, Malta, Italy, and Spain, have been visited during the present century, the disease is now mainly confined within the Asiatic boundary and seldom threatens the invasion of Europe. But the necessity for quarantine did not cease on the subsidence of this disease, for yellow fever from the West Indies and certain parts of tropical America occasionally ravaged the seaports of Southwestern Europe, and more recently cholera from India has spread epidemically in the pathways of commerce. The former was first imported into Spain from Havana in 1741; but its appearance on European soil exercised no modifying influence on quarantine measures—those in use against the plague were applied for the exclusion of this new exotic. The latter made its first progress through Europe in 1830; and as its westward track from its origin in India was well recognized, the quarantines at the Mediterranean ports became considerably relieved and Western civilization protected by the establishment of special quarantine stations for the interception of the disease in the Red Sea and at points on the overland route.

About this time the severity of the requirements of quarantine became lessened. The natural history of epidemic disease was better known, and instead of an arbitrary detention of so many days the period became based on that of the incubation of the disease to be excluded. Thus in France, in 1847, vessels from infected ports in Turkey and Egypt were admitted without restraint, if ten days had been consumed in the voyage and no disease had appeared on board in the meantime. An imperial decree, in 1853, admitted such vessels at once into the Atlantic ports of France, and into the Mediterranean ports if eight days had elapsed since leaving the port of departure. Steamers from Alexandria to Marseilles landed their mails at once, however short the voyage, but passengers were detained until the period of eight days had passed. Vessels from infected ports were quarantined for ten days after arrival at any of the ports of the empire, and their cargoes for ten days after their removal at the quarantine station. These regulations had regard to plague. With respect to cholera, vessels from infected ports were, in the Mediterranean, subjected to a quarantine of five days including the voyage, and in the Atlantic ports to one of three to five days when one or more cases of the disease had occurred on the voyage; but no quarantine was imposed on the cargo. Vessels from places infected with yellow fever were quarantined from three to seven days at the Mediterranean ports, but had free entry on the Atlantic coast if no sickness or death had occurred during the last ten days of the voyage.

In this country quarantine was instituted against yellow fever from Barbadoes, and typhus and small-pox from the other side of the Atlantic. Philadelphia suffered from the Barbadoes distemper in 1699, and in the following year the Province of Pennsylvania endeavored to secure protection in the future by passing an "Act to prevent sickly vessels from coming into this Government," which required, under penalty of one hundred pounds, that such vessels should come no nearer than one mile to any of the towns or ports of the province, nor land goods or passengers until they had received a license from the proper authorities. Massachusetts enacted a quarantine law in 1701 against vessels infected with plague, small-pox, pestilent or malignant fever, or other contagious disease, or coming from places where such maladies prevailed, prohibiting all communication between the infected or suspected vessels and the shore. In 1758 the colonial legislature established quarantine at New York by an act to prevent the bringing in and spreading of infectious diseases in the colony. After the successful passage of the Atlantic by cholera in 1832, this disease became added to the list of exotic pestilences which it was the object of quarantine to exclude.

Based originally on the theory of contagion, quarantine measures were directed to the detection and isolation of infected individuals, but the transmission of disease by fomites placed restrictions also upon goods, particularly such as experience had shown to be efficient carriers of the morbific matter. This interference with the liberty of the individual, combined with the financial interests involved, raised a continued opposition to quarantine detention, which became more outspoken on every fresh demonstration of the inability of this measure to accomplish its object. Indeed, the burdensome nature of the restrictions led in many instances to their evasion and consequent failure to protect the community. Unfortunately there were many such failures in the operation of every quarantine; and the opposition did not hesitate to affirm that the quarantine system was a barbarous imposition of the middle ages, of no value as a protective measure, and operating merely as an impediment to commerce. The reply to this acknowledged the inability of quarantine to guarantee protection, but claimed that the chances of importation were reduced in proportion to the care with which the regulations were enforced. "Shall we," as Sir Sherston Baker says, "abolish the fire brigade because a row of houses are burned down? Shall we dismiss the police force because a dozen burglaries have occurred? Shall we denounce the system of railway signalling because a false signal has caused a fatal catastrophe?"

The immense importance of her commercial relations to England has made that country a leader in the establishment of a sanitary system which will give adequate protection without imposing the burdensome restraints of former times. Originally her quarantines, directed against the plague, were formulated on those in existence at the Mediterranean seaports; but since cholera became the pestilence specially to be guarded against, a system of sanitary inspection has been urged for adoption at the Red Sea stations, and accepted as the only needful measure at her home ports.

Quarantine regulations did not take practical shape in Britain until the beginning of the present century. Consular officers at foreign ports furnished bills of health to vessels clearing for the United Kingdom. A *clean* bill implied that no infectious disease existed at the port of departure at the time of sailing, nor had existed for forty days prior to that time. This did not entitle the vessel carrying it to free pratique unless the superintendent of quarantine was satisfied that her crew and cargo were free from suspicion; and, indeed, all vessels laden with cotton from Alexandria were obliged to undergo quarantine irrespective of the character of their bills of health. A *suspected* bill was given to vessels when the port of departure, although free from disease, had commercial relations with infected ports or places. A *foul* bill was issued when the port of departure was itself infected. All vessels coming from a port which had been officially declared dangerous in view of the existence of plague or other infectious disease or distemper, and all vessels, boats, persons, or goods that had been in communication or contact with any vessel so coming or having touched at an infected port, were declared liable to quarantine. Against yellow fever from America or the West Indies an inspection station was provided, that the health of the crews of incoming vessels might be ascertained, but such vessels were not subjected to quarantine unless specially ordered. The Privy Council was authorized to make such orders,

upon emergencies, as it might consider necessary. Masters of vessels from foreign ports were required to give to pilots an accurate account of all the places at which they had touched on the homeward voyage; and it was incumbent on the latter to give information of any change in the regulations, involving the liability of a vessel to quarantine restrictions, that masters might be assumed to be ignorant of by reason of their recent voyage. At the port of destination, in suspicious cases, a quarantine inspector interrogated the incoming vessel from a proper distance, to ascertain the sanitary condition of the port or ports at which she had touched on her homeward voyage, and the history and character of any sickness that may have affected the crew or passengers; if he found her liable to quarantine, she was obliged to proceed to the station, as the naval, military, and civil powers of the government were subject to calls for the enforcement of the laws. When the vessel reached the quarantine station a full record of her sanitary condition and history was made, and if she was reported by the superintendent as fit for entry into her port of destination without further detention, the Privy Council was authorized to direct her immediate release. Vessels with clean bills of health from the Mediterranean and West Barbary on the Atlantic Ocean were required to undergo a limited quarantine, for the purpose of breaking open the cargo and airing it prior to delivery; and certain places were appointed as quarantine stations for this purpose, such as Standgate Creek for vessels bound for the ports of London, Rochester, and Faversham; Milford Haven for Carlisle, Liverpool, etc.; Inverkeithing Bay for the eastern ports of Scotland; and so for other sections of the coast. These vessels were detained fifteen days from the date of their arrival, during which time all goods were aired on deck; but if the cargo of the vessel consisted in whole or in part of certain classes of goods conceived to be of a retentive or dangerous character, these were required to be removed for aëration to a special quarantine float, and the detention of fifteen days dated from the time of the discharge of the cargo. The list of dangerous articles was long, and included all cotton, silk, and woollen goods, furs, straw, etc. Vessels with suspicious bills were detained at the station for thirty days, during which they were daily subject to inspection; and if at any period of their stay a pestilential disease was discovered among the crew or passengers, the quarantine period was recommenced and the vessel treated as newly arrived and plague-stricken. Vessels liable to quarantine were required to indicate their condition when passing other vessels or approaching the coast by flying a yellow flag or showing a light at the mainmast-head. Merchant-vessels with foul bills, but not having the plague on board, were restricted in their choice of quarantine stations to Standgate Creek and Milford Haven, where there were better facilities for caring for the sick and handling suspected cargoes. War-ships under similar circumstances repaired to a special station at Motherbank, where a floating lazaret was established for their benefit. If plague appeared on a vessel while *en route*, she was required, if to the southward of Cape St. Vincent, to proceed to some lazaretto in the Mediterranean, there to undergo quarantine; and on her arrival on the coast of the United Kingdom she reported to the superintendent of the station most convenient for her, and awaited the special orders of the Privy Council in her case. All other plague-stricken merchant-vessels repaired to the quarantine grounds marked out at Milford Haven by twelve yellow buoys. Here guardians were appointed to see that these ships were thoroughly searched and cleaned after the removal of their cargoes. No communication was held with them except by letters which had been dipped in vinegar and fumigated; and nothing was delivered without the quarantine lines from on board except on the order of the superintendent. The sick were transferred to a floating hospital; separate accommodations were provided for the healthy and for convalescents and invalids during the period of their detention; the cargoes were unloaded for aëration and disinfection, and the vessels subjected to thorough cleansing and fumigation. In case of death at quarantine the body was required to be sewed up in canvas, weighted with one and one-half hundredweight of iron, and committed to the deep, the infected clothes and bedding being destroyed. The government provided medical attendance, medicines, disinfectants, and the use of the quarantine floats, shelters, furniture, and appliances, free of expense to the detained vessels, and no quarantine fees were charged.

In 1871 the powers and duties relating to quarantine and public health vested in the Privy Council were, as regards England and Wales, transferred to the Local Government Board. Two years later, when cholera was prevalent in certain parts of Continental Europe, the Board issued orders with a view to the better protection of the country from epidemic invasion. The officer of customs was required to detain any suspected vessel for inspection, immediately notifying the port or local sanitary authority; but if no action was taken thereon within twelve hours, he was authorized to release the vessel. The local sanitary authority was required to cause the immediate inspection of any suspected vessel, whether detained by the officer of customs or not, to ascertain whether she was infected. Healthy persons were permitted to land without delay; those affected with diarrhœa or other suspicious sickness were detained on board or in some previously appointed place for a period not exceeding two days, for the determination of the character of their illness; those certified as affected with cholera, and those suspects who developed disease during their temporary detention, were removed to some appointed place, or, if unfit for removal, were retained on the vessel, which they were not permitted to leave save on the authority of the proper officer. The vessel and her contents were required to be disinfected, dangerous articles, such as the clothing and bedding of those who had suffered, being destroyed if considered necessary.

The local authorities of English ports, under the supervision of the Local Government Board, make provision, at the present time, for the relief of vessels suffering from other dangerous infectious diseases, as diphtheria, erysipelas, measles, small-pox, scarlet, enteric, typhus, and relapsing fevers; and for this purpose floating hospitals are sometimes used. That launched at Newcastle-on-Tyne in August, 1886, may be instanced as one of the best construction, not only as being the latest, but as the product of a port noted for its ship-building industry (see Fig. 3225). It is built on ten cylindrical iron pontoons resembling huge boilers, each 70 feet long, 6 feet in diameter, and having a buoyancy of $53\frac{1}{2}$ tons, so that the floating power of the hospital is equal to 535 tons. On each pontoon are seven saddles, which support a strong framework of longitudinal rolled-iron girders braced together by diagonal T-iron. This supports a deck of creasoted timber, which constitutes a platform on which the hospital is erected. It is surrounded by a neat handrail, and access from the river is obtained by a gangway in the front centre of the protection-rail. The deck is partly occupied by three main buildings, six smaller structures, and a mortuary. Each of the main buildings, $65 \times 23\frac{1}{2} \times 20$ feet, is divided into two wards, one containing six, the other four, beds. The interiors are spacious, lined with polished pitch-pine in narrow strips, well lighted and ventilated by inlet apertures near the floor and a shaft through the roof fitted with Kiles' patent ventilator. Between the two wards of each building is an apartment for the nurse, fitted on either side with glazed doors to afford full view of each ward. The three buildings are all fitted up alike, and are so arranged that each can be completely isolated. As the platform is 140 feet long by 80 wide, there is ample space in front of the buildings for the recreation of convalescents. Beneath the floor is a clear space of ten inches, to secure free access of air between it and the deck; and between the platform and the water-level is a space of four feet. The rise and fall of the tide and the current in the spaces between the pontoons prevent the possibility of any impurity beneath the hospital. The space between adjoining pontoons is $14\frac{1}{2}$ feet from centre to centre, and each is detachable for cleaning, painting,

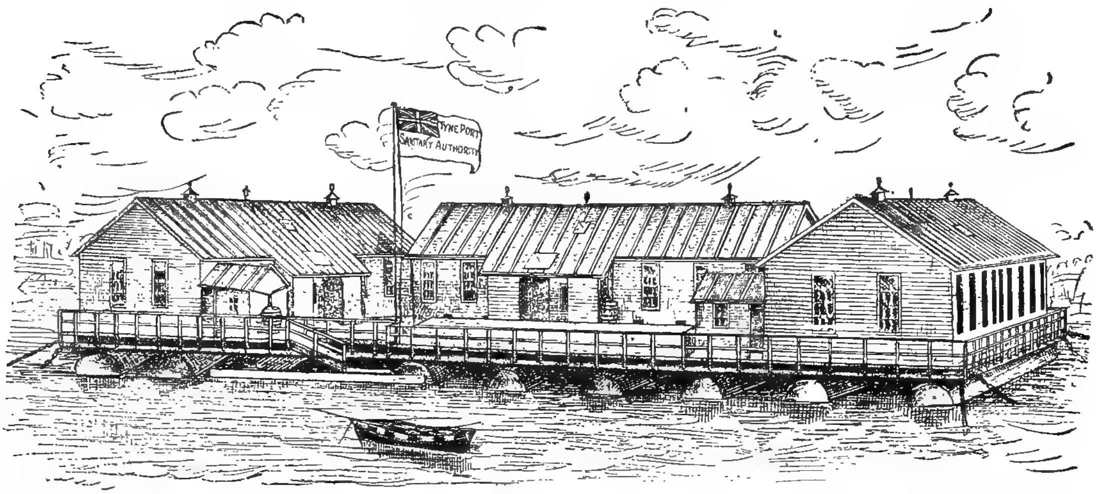

FIG. 3225.

or repairs; they may also be revolved in their places without removal.

The gradual progress of the emancipation of commerce from the onerous impositions of earlier times, and the better protection of Europe from plague and cholera by measures based on the scientific study of disease, may be best appreciated by following the history of the international conferences that have been held from time to time.

In July, 1851, an international conference on the subject of quarantine was held at Paris, delegates from most of the European states being present; the results of its deliberations were subsequently ratified by France, Sardinia, Portugal, Tuscany, and Turkey. Only foul and clean bills of health were recognized by the convention, the first for the assured presence of the malady, the second for its attested absence; and for the more easy application of quarantine measures a maximum as well as a minimum of detention was agreed upon. For the plague, ten to fifteen days; for yellow fever, three to seven days for vessels without casualty during their voyage, and seven to fifteen days for those having had sickness *en route;* for cholera, three to five days, including the duration of the voyage, but if cases occurred *en route* the time occupied by the voyage was not taken into account. Merchandise was divided into three classes: 1, Articles subject to an obligatory quarantine and purification—these included old clothes and articles of common use, rags and waste-paper, leather and skins, feathers, hair, and, in general, any parts of animals, and, lastly, wool and silk stuffs; 2, those liable to quarantine, including cotton, flax, and hemp; and 3, those exempt from all restrictions, comprising all articles not belonging to the first or second class. Each of the contracting parties agreed to furnish and maintain the lazarets required by the exigencies of the public health, the convenience of travellers, and the requirements of commerce; and in order not to impose on the shipping of their respective states more than the charges needful to cover the expenses of maintenance, certain dues and taxes were indicated. Sanitary councils were established in the principal ports and cities, and the consuls of states accepting the terms of the convention were entitled to be present at the deliberations of these councils and to be heard when the interests of their country were involved. The regulations provided for the thorough cleaning of all merchant-vessels at the port of departure before taking in their cargo, and for the medical examination of the crew and passengers. Certain measures of cleanliness and ventilation were required to be carried into effect during the voyage. On arrival at the port of destination the vessel was inspected and admitted to free pratique or detained to effect the requisite cleanliness, for a quarantine of observation, or for the performance of a strict quarantine, as seemed necessary from her history and condition. Strict quarantine involved purification and disinfection. The occurrence of yellow fever, cholera, or plague during the period of detention necessitated a renewal of strict quarantine. Regulations were formulated for the arrangement, supervision, and interior management of lazarets, including the disposition of cargoes, wearing-apparel, and mails. Provision was also made for the sanitary supervision of Turkey and Egypt. The Superior Council of Health at Constantinople, which was to superintend this service, had added to its membership a number of delegates from the states signatory to the convention equal to that of the Ottoman functionaries and having equal voice with them in the deliberations. At Alexandria a similar board of health was constituted. Medical inspectors, appointed by the powers interested, were distributed over the East to study, in relation to the public health, the country in which they were stationed, its climate, diseases, and characteristics, and the means adopted to combat the disease; and to this end they were required to make tours of inspection through their respective districts as often as deemed desirable. In case of an epidemic or suspicious outbreak these inspectors were required to report immediately to superior authority. These regulations were in force for five years, but were not renewed at the end of that period.

The Conference of Constantinople, in 1866, enunciated certain guiding principles of practical action. It recognized the origination of cholera under certain unknown conditions and its endemic existence in India, particularly in the valley of the Ganges; the possibility of its naturalization on European soil was considered problematic. Its propagation was effected, not by atmospheric conditions, but by the agency of man, and with a rapidity proportioned to the speed of his methods of travel. The cholera patient, or person suffering from premonitory diarrhœa, was the chief agent in its spread, the choleraic discharges being regarded as the dangerous element. The period of incubation did not exceed a few days. It was considered reasonable to suppose that living animals were capable, in certain cases, of transporting the disease. Articles in common use by choleraic patients and their attendants were efficient transmitters—even from afar, if protected during transportation from the action of the air. The possibility of its transmission by merchandise was admitted, in the absence of proof, and it was pronounced safest to consider as infected and dangerous all productions of an infected locality. Moreover, although there was no positive evidence of danger from the bodies of choleraic dead, it was considered prudent to regard and treat them as infected. Sea and railroad travel were announced as the most dangerous methods of communication, while deserts traversed only by caravans were regarded as an effectual barrier to the transmission of the disease. All

aggregations of men, pilgrimages, fairs, armies, etc., favored the extension of cholera, while its violence was proportioned to the absence of immunity on the part of individuals and to general insanitary conditions, as poverty, overcrowding, deficient ventilation, and impurity of soil, particularly if the impurity is in part derived from choleraic dejections. On shipboard, intensity is proportioned to overcrowding with susceptible material; but the danger of importation has no relation to this intensity. So, in a lazaret, the aggregation of persons coming from a place where cholera prevails does not produce a great increase of the disease among them, owing to their relative immunity; but such a lazaret is dangerous to its susceptible neighborhood.

As relating to prevention: The conference appreciated the efforts of Britain to restrain and extinguish the disease in India by general and special sanitary measures, but concluded that as these could not be efficient at an early date, it was meanwhile needful to guard against importation. For this purpose a system of maritime sanitation was suggested, and it was advised that there should be: Competitions and prizes for discoveries or improvements the immediate results of which would promote the sanitary condition of vessels, the health of their crews, and the well-being of their passengers; a manual of hygiene for the use of the merchant-marine of every country, the most important rules of which should be obligatory; and encouragement by premiums and rewards to those who should distinguish themselves by the excellent management of their vessels and crews. The sanitary conservation of ports was considered as of great importance; this included the exclusion of city sewage from the waters of the harborage and measures of general cleanliness, having reference to purity of air, water, and soil, particularly the protection of the last from choleraic infection. It was held that restrictive measures, properly applied, did less harm to commerce and international relations than the disturbances consequent on epidemic visitation, and that quarantines, based on rational and scientific views concerning the transmissibility of cholera and its mode of propagation, were an efficient barrier against its importation. As the disease came from India by way of the Red Sea, overland through Persia, or from secondary foci in Arabia, all these modes of progress were reviewed, and appropriate recommendations given. The establishment of a quarantine station in the Red Sea, under international control, was advised, with special stations for vessels carrying pilgrims. A sanitary service for the protection of the overland route was suggested, with a quarantine of ten days when the arrivals had not been more than three days on the journey; the immediate sequestration of first cases was approved, together with the early isolation of an infected locality and the use of sanitary cordons, which, although of uncertain value and often dangerous in wide-spread epidemics and dense populations, were regarded as affording good results in limited localities or sparsely settled countries, as in some parts of Asia. A special sanitary service was also recommended for the Hedjaz and its pilgrimages, involving non-intercourse between Arabian and Egyptian ports during the progress, and for fifteen days after the cessation, of any cholera epidemic among the aggregations of pilgrims. Islands otherwise unoccupied, or isolated localities distant from centres of population, with good air and water, a rocky and non-malarious soil and ample harborage, were recommended as quarantine sites. Floating lazarets were not considered satisfactory. Quarantine quarters were to consist of one-story cottages, each of four rooms, with accommodation for five persons in a room; the distance between adjacent houses to be twenty metres, and that between adjacent rows one hundred metres. The hospital, including officers' quarters, dispensary, wards, kitchen, laundry, and store-rooms, to be at least two hundred metres distant from the quarters, and to be formed of a similar series of detached cottage-buildings, each ward to contain from five to ten beds. Two landings to be provided, one for persons and goods subject to quarantine, and the other for unrestrained commerce; warehouses to be near the landings, with special accommodation for goods requiring purification, and stables and sheds for animals. Movable vessels, charged with disinfectants, to be used in the privies of all sections of the establishment, their contents thereafter to be buried under quick-lime and animal-charcoal. Quarters of the quarantine guard to be at least two hundred metres from other buildings. It was considered advisable that stations thus equipped to carry out the measures of a strict quarantine in the case of infected vessels should be as few in number as was consistent with the requirements of the traffic and coast-line of a state. Quarantines of observation, which involved watching merely, might be performed without inconvenience or danger at less elaborate stations, or even on shipboard in the vicinity of large ports. The quarantine period was fixed at ten days; but vessels in which all sanitary precautions had been taken, including inspection at the port of departure, and which carried a commissioned medical officer, had the time spent on the voyage included as part of the quarantine period. Vessels on which no suspicious disease was developed during the voyage were merely detained, or subjected only to such general hygienic measures as seemed desirable, and if the voyage had lasted fifteen or more days the quarantine was reduced to five days. Those which were infected had to discharge cargo and submit to special means of purification, as by fumigation with chlorine. Those in which a severe epidemic had occurred were to be treated with the utmost precaution, even to prolonging or doubling the ordinary period of detention.

The Conference of Vienna, in 1874, adopted the conclusions reached at Constantinople concerning the origin and transmission of cholera. Land quarantines were rejected as inefficient and impracticable, in view of the increasing facilities for communication and the injury they inflict on commercial interests. The substitution of a system of medical inspection for quarantine at European ports, with the establishment of a rigorous and truly preservative quarantine during the passage of the Red Sea, was strongly urged by Semmola, of Italy, in submitting to the conference the report of a sub-committee on seaport quarantines. The Red Sea was considered the strategic point in the line of defence against cholera invasion. Hirsch, of Germany, and D'Alber-Glanstätten, of Austria, also spoke in favor of these views, which were vigorously attacked by Sousa-Martins, of Portugal, who was inclined to hold that, outside of quarantine, science recognized no sure means of preventing the importation of cholera; that the failure of quarantine measures was caused by the neglect or infringement of the laws governing the propagation of the disease, and that commerce suffers more from epidemics than from quarantines. The committee, he argued, must be of the opinion that quarantines were based on scientific views, since they had been accepted by its members, who were scientific men; that they were practicable, else they would not have been recommended as the only defence of Europe against invasion, and that at Suez and Alexandria, at least, they were less to be feared in their economic consequences than the evils consequent on the diffusion of epidemic cholera. But why confine the application of these accepted principles to the towns mentioned? Was quarantine more efficacious there than elsewhere? Was there more likelihood of arresting the progress of an epidemic at its points of irruption than at places where its progress was less rapid? Would cholera be less fulminant at Suez, where pilgrims arrived by the thousand, than at Marseilles, Gibraltar, or Lisbon? Have the ports of Europe fewer facilities for carrying out quarantine measures than those of Egypt, or do Alexandria and Suez present topographical conditions which do not exist in Europe? He charged the committee with conceding that, in the event of the introduction of the disease, its epidemic diffusion was certain notwithstanding all quarantine measures. Was amputation of no avail when gangrene supervened? Yet it was acknowledged, by the recommendation for a Red Sea quarantine, that the only protection available for

Europe lay in these same quarantine measures. There was inconsistency in this. The report of the committee was defended by several of its members, the principal argument being that when cholera passed the Red Sea and appeared in Europe, European quarantines could do no more than attempt the isolation by sea of countries that were in daily communication by land. M. Fauvel, in objecting to the withdrawal of European quarantines, argued that in some countries sanitary interests, in others commercial interests, were prominent, and that the utility of quarantine was regarded differently according as one or the other of these interests predominated. The northern countries of Europe, besides having been less devastated by choleraic epidemics, had more exacting commercial interests than the southern countries, and were therefore inclined to view quarantines only as impositions or restrictions on their commercial relations. Even the same government did not always view the question of quarantine from the same stand-point. England, although desiring no quarantine at her home ports because commercial interests were superior to all others, did not hesitate to impose the most rigorous measures where these interests demanded the protection of a port from infection. At Malta the strictest quarantine of the Mediterranean was in force, and at Gibraltar suspected vessels had been refused admittance. In France the channel ports coincided in the views of the northern countries, the Mediterranean ports with those of the south. All are actuated by the dominant interest. To say that seaport quarantines are useless because cholera may come by land is an argument invoked only in behalf of interests that have not the public health for their objective. We know that quarantines prevent importation. They do not guarantee safety; but why should that perfection be required of quarantine that is not required of any other human institution? It is true, also, that seaport quarantines lose much of their value when directed against an epidemic in their immediate neighborhood. But we must be content with the best possible protection. If the means of prevention employed increase in some degree the chances of preservation, and do not involve sacrifices greater than the guarantee of protection afforded, they should be considered advisable and worthy of adoption. As a result of these discussions, the conference approved the recommendations of the Conference of Constantinople concerning the establishment of a strict quarantine in the Red and Caspian Seas to prevent the introduction of cholera into Europe. In the event of invasion a system of medical inspection was recommended, but for those states which preferred to continue quarantine restrictions certain regulations were adopted.

The *inspection system* provided that every commercial port should have a sanitary service competent to deal promptly with all vessels, crews, and passengers. Vessels from a healthy port, not having touched at an intermediate suspected port or communicated directly with a suspected vessel, and having had no sickness of a suspicious nature during the voyage, were admitted to free pratique. Arrivals from a suspected or infected port, or those having had compromising relations or suspicious sickness during the voyage, were to be submitted to a rigorous medical inspection, when, if no infection was discovered, the vessel and all on board were granted immediate admission; but if it was found that cholera or sickness of a suspicious nature had existed on board before arrival, the vessel and the clothing and other articles in common use by the crew and passengers were to be carefully disinfected. If the incoming vessel contained persons sick or dead from cholera, the sick were removed to a lazaret or other proper place and the dead committed to the deep or buried after suitable disinfection, and the crew and passengers, their effects, and the vessel itself thoroughly disinfected, but the cargo, save when consisting of rags or other susceptible articles, was admitted without treatment.

The *quarantine regulations* for arrivals from infected ports provided for a period of observation ranging from one to seven days when no disease was present on arrival; but at the eastern ports of Europe, and elsewhere in exceptional cases, this period was extended to ten days. If proof was found that no suspicious case had occurred during the voyage, three to seven days' detention was required; but if the voyage had lasted at least seven days, the period of observation was reduced to twenty-four hours; and these quarantines might be performed on board the vessel, provided she was in suitable sanitary condition. When cholera had occurred during the voyage or after arrival, persons not sick, except such as were required for the care of the vessel, were isolated in a lazaret or other suitable place; the sick were landed and cared for separately, and the vessel and all susceptible articles were disinfected, after which those persons who remained on board were kept under observation for seven days. For arrivals from suspected ports, and in the absence of any suspicious accident during the voyage, the period of observation was limited to five days. Emigrant and pilgrim ships and others deemed particularly dangerous to the public health became the object of special precautions, to be determined by the port sanitary authority. When the port of arrival was unprovided with proper quarantine facilities, an infected ship was to be directed to the nearest lazaret after receiving such succor as her condition required. A vessel coming from an infected port, but having touched at an intermediate port, where she had received free pratique without having undergone quarantine, was to be treated as coming directly from an infected port. In cases of mere suspicion, disinfection might be resorted to when considered expedient by the sanitary authority, but it was not to be regarded as obligatory. A port in which cholera prevails epidemically should cease to quarantine, and practise only measures of disinfection. For inland river towns the system of medical inspection was recommended as applicable. It was decided, as pertinent to both the inspection and the quarantine system, that the captain, medical officers, and other officers of a ship are bound to furnish to the sanitary authority every information concerning the occurrence of suspicious disease among the crew or passengers, and in case of false representations or wilful concealment they are liable to penalty under the sanitary laws, on which subject it was considered desirable that there should be an international agreement. The details of disinfection were left to the sanitary authorities of each country. The conference also recommended the institution at Vienna of a permanent International Sanitary Commission, having for its object the study of cholera and other epidemic maladies from the stand-points of etiology and prophylaxis, and the coordination of researches into these subjects undertaken by the various contracting states.

The English delegates at this conference urged the adoption of the system of medical inspection instead of arbitrary quarantine rules, and presented a communication from the Medical Officer of the Privy Council giving the views of the Local Government Board on the propagation of cholera in England. These held importation of the infection to be of secondary importance; local filth and unsanitary conditions which afforded the imported infection a soil favorable for its development were regarded as the principal agencies. The precautions to be taken embraced the removal of the filth, the protection of water-supplies, and, in the event of invasion, the disinfection of choleraic discharges, in which the infective power is known to reside. But the main object of England at this conference was evidently to secure such action as would permit her vessels from India to traverse the Red Sea without embargo by either quarantine laws or international inspections. Something was accomplished in this direction before the Superior Council of Health at Constantinople in 1882. The delegate from England, in presenting a communication from the Governor-General of India opposing quarantine restrictions on English vessels from India, represented that the fears of an importation of cholera were based upon the theoretical views of the Conferences of Constantinople and Vienna, and not upon facts. Aden, he instanced, is in daily communication with Bombay and other Indian ports, which are distant but a few days' journey, yet it

has not suffered from the disease during the years 1868–80, and its history, so far as known anterior to 1865, confirms the experience acquired since that time. After full discussion the council adopted certain propositions recognizing the great danger of the introduction of cholera by the often foul and always crowded ships carrying pilgrims to Mecca, and authorizing the free admission of vessels in good sanitary condition, having no pilgrims on board and no suspicion of cholera during the voyage, inasmuch as no instance has been recorded of the introduction of the disease by vessels not carrying pilgrims, and permitting arrivals under these conditions from ports that are known to be infected to have the duration of the voyage considered as part of their quarantine term, which shall be completed by twenty-four hours of observation.

Meanwhile an International Conference was held on this side of the Atlantic. It was called by the President of the United States, in compliance with a joint congressional resolution, for the purpose of securing an international system of notification as to the actual condition of ports and places likely to be infected with cholera or yellow fever, and the establishment of a uniform and trustworthy system of bills of health. The exposure of this country to yellow fever, and the difficulty experienced by our consuls at foreign ports in obtaining the co-operation of the local authorities in their efforts to verify and improve the sanitary condition of vessels clearing for United States ports, were the chief agencies in the inception of this conference. It was held in Washington in the early part of 1881, and thirty-one governments were represented at its sessions. The resolutions adopted looked to: 1. The establishment by each government of such an organized internal service as would enable it to be regularly informed of the state of the public health throughout the whole of its territory. 2. The publication, weekly, of the mortality statistics of its principal cities and ports. 3. Direct communication between the sanitary authorities of the countries concerned. 4. The creation of international organizations for the collection of information regarding the outbreak, spread, and disappearance of cholera, pest, yellow fever, etc., and conveying such information to the parties interested. 5. The acceptance by the authorities of the various countries of a bill of health after the form approved by the conference. 6. The delivery of the bill at the port of departure by the territorial sanitary authorities, and the right of the consul of the country of destination to be present at the examination of ships, to authenticate the bill, and to make thereon such remarks as he might deem necessary. 7. Gratuitous issue of the bill. 8. The creation of a temporary scientific sanitary commission by the nations most directly interested in protecting themselves against yellow fever, and of such others as might wish to take part in this arrangement, for the purpose of studying all matters pertaining to the origin, development, and propagation of that disease.

Had this conference restricted its efforts to the ends for which it was specially called, it is probable that a convention might have subsequently ratified its conclusions, and international communication relative to epidemic diseases, with uniform rules pertaining to the issuance of bills of health, might have been obtained as a protection to both the public health and the interests of commerce; but, unfortunately, some enthusiastic sanitarians urged the adoption of the eighth resolution, which, by calling for the establishment of twenty-two international posts for the study of yellow fever, each provided with chemical and histological laboratories, libraries, and expert physicians for their use, with provision for an annual conference, at which at least one member from each post should be present, implied a financial expenditure for its support sufficient to prevent any practical action from being taken on the conclusions of the conference, if it did not throw doubt upon the whole of these conclusions as being apparently the work of medical visionaries. As it was, no action was taken by the Government to realize any benefit from the deliberations of the conference.

The last conference was convoked at Rome, in May, 1885, by the Italian Government, with the view of settling the basis of an international agreement as to measures of prevention that would be acceptable to all the governments, and of forming rules for the application of such an international system of sanitary intelligence as had been proposed at Washington in 1881. The following summarizes the conclusions of a technical commission consisting of the medical delegates, to which the duty of preparing suitable resolutions was referred: It was considered necessary that there should be in every country a central bureau for the interchange of information concerning sanitary conditions, for the publication of an international bulletin giving weekly bills of mortality from all important cities, and for the transmission of telegraphic notice to all concerned of the extension of cholera or yellow fever to new localities. Under the heading of Sanitary Prophylaxis in Cholera, it was considered that purification and isolation, in the measure indicated by science, of everything that may carry the infection of cholera were the best means of preventing the importation and propagation of that disease. As disinfectants, steam, carbolic acid, and chloride of lime were recommended; for certain articles, boiling in water for thirty minutes, and when these measures are impracticable, destruction or an aëration by exposure for three or four weeks. Disinfection of merchandise and mail-bags was not considered needful; but superheated steam was suggested, parenthetically, as the only available means if the disinfection of rags in bale was desired. Land quarantines and sanitary cordons were affirmed to be useless; the propagation of cholera by land was to be combated by general sanitary measures, taken in advance, and the prompt isolation of newly developed cases, with effective disinfection under the supervision of an organized sanitary service. Travel by rail from infected places was to be effected under medical guardianship, which had at each station means of isolation for cases developed *en route*. In passing into an uninfected district, passengers and freight were to be transferred to other cars, that those from the infected territory might be retained within it. Disinfection of passengers and merchandise was declared to be necessary only when there had been contact with choleraic dejections. River-ports open to sea-going vessels were considered seaports so far as concerned protective measures; but interior river navigation required rigorous medical inspection, stations being provided for the treatment of infected vessels.

The importance of general sanitary measures at seaports was urged. These should be effected under the supervision of a special sanitary authority. The consul at the port of departure should have the right of assisting at sanitary inspections of vessels made by the territorial authority, in conformity with the rules established by convention or treaty. The lading of the vessel at the infected port should be begun only after thorough cleaning by ordinary means or specially by disinfection, as might be required. The crew and passengers should be examined, and those suspected of choleraic disease should not be permitted to embark, nor should any suspected bed- or body-linen or other articles be admitted on board. These measures devolve on the captain and medical officer of the vessel prior to inspection by the territorial authority; but if the vessel does not carry a medical officer, the consul of the port of destination should appoint a suitable person to perform these duties.

Recommendations were made for the management of the vessel during the voyage, and particularly in case of the development of choleraic disease. All steamers passing through the Red Sea from infected Indian ports should be subjected to inspection by an independent, *i.e.*, an international official, and if the medical officer of the vessel certifies that all necessary precautions have been taken at the port of departure and during the voyage, and that there is no one on board affected with cholera or any sickness of a suspicious character, free pratique should be accorded by the inspecting officer. Vessels with passengers for the ports of Egypt or the Red Sea

should be inspected near the Straits of Bab-el-Mandeb, and again on arrival at the port of destination; but those passing through the sea merely *en voyage* require inspection at Suez only. If at the inspection the vessel is found to be infected, the passengers should be landed, the sick isolated and properly cared for, and the others subjected to observation for five days, while the ship, clothing, bed-linen, and other suspected personal effects are disinfected. Vessels not carrying a medical officer should be subjected to two inspections, one within the straits and the other at Suez, although they may be merely *en route* to the Mediterranean and have no commerce with the Egyptian or Red Sea ports. Special provisions of a more rigorous nature were adopted for the treatment of ships carrying pilgrims from India to the Hedjaz, and for those returning from the pilgrimage to Egyptian or Mediterranean ports.

On arrival at European ports suspected vessels were to be considered entitled to free pratique only when inspection in the daytime by the medical officer of the port revealed that all needful precautions had been taken before sailing and on the voyage, that no case of a suspicious character had occurred on board, and that ten days at least had been spent *en route*. If this period had not elapsed since leaving port, a detention of twenty-four hours was required for observation, with disinfection of soiled linen and other suspected personal effects. In the case of infected vessels, the port sanitary authority should cause the landing of the crew and passengers, the sick to be isolated and cared for, the well to be under observation, and the vessel, personal effects, and other dangerous articles to be disinfected. The period of observation was limited to five days; but if no case of cholera had occurred on board for ten days, the detention was reduced to twenty-four hours, as in the case of vessels merely suspected. Suspected vessels from Mediterranean ports were required to disembark their crew and passengers at a suitable place for observation, the period to be limited to from three to six days including the time spent on the voyage. Infected vessels were to be treated as in the case of those bringing the disease from India or the Red Sea.

The summary of the conclusions of the technical commission of this conference does not contain the word "quarantine" in connection with preventive measures to be taken at seaports, but it does not follow that the abolition of quarantine was recommended in favor of a system of medical inspection. On the contrary, the commission, while disusing the word, insisted on the measure with more force than did the Vienna Conference. The latter left the option of quarantine or sanitary inspection to the countries concerned, but the former imposed a detention of twenty-four hours in cases where the sea-voyage from suspected ports beyond the Mediterranean had lasted less than ten days, and a quarantine of from three to six days on suspected vessels from Mediterranean ports, with no proposition looking to the system of medical inspection as an alternative.

Having thus reviewed the efforts made by Europe to supersede arbitrary time-quarantines by protective measures based upon a knowledge of the natural history of epidemic diseases, we may turn to this country to learn in what manner medical progress has affected the local quarantines established in colonial days. It will be seen that here, as in Europe, the tendency of the time is to secure the greatest possible protection to the public health with the least possible injury to commercial interests, to abolish quarantine detention, substituting for it a system of medical supervision which will obviate the necessity for detention except in the case of manifestly infected vessels.

Quarantine powers have always been regarded as belonging to the States, and although several efforts have been made to secure the enactment of a general quarantine law, these have failed, apparently from the disinclination of the States to cede their powers in this respect to the General Government. The wide-spread devastation caused by yellow fever led, in 1796, to the discussion of a national bill for the regulation of quarantine. This authorized the President to institute quarantine at ports of entry, and to specify its duration. Its second section directed the use of the revenue service in carrying out the quarantine law and the health laws of the States. The power of dictating and regulating quarantine, to be vested in the President, was voted down by the House of Representatives, but the second section was passed. To this the Senate attached an amendment, implying the bill to be merely a temporary aid to existing protective measures, which should remain in force only until general regulations relative to quarantine were made by law. But this assertion of the power of the National Government to regulate quarantine was objected to in the House of Representatives, and the second section of the original bill was passed without amendment. This was followed and repealed, in February, 1799, by an act in which the possession and exercise of quarantine powers by the States was fully and distinctly recognized, certain Federal officers, such as all officers of the customs, masters of revenue-cutters, and military officers commanding posts or stations on the seacoast, being required to aid in the execution of the quarantine and health laws of the States, according to their respective powers and within their respective precincts, and subject to the direction of the Secretary of the Treasury.

For nearly three-quarters of a century no further effort was made to protect the country by national legislation. Meanwhile its quarantine laws became a heterogeneous conglomeration of impositions on commerce, without affording commensurate protection. Some small ports on the Gulf and Southern parts of the Atlantic seaboard, which, from their relations with the West Indies, had more or less familiarity with yellow fever, imposed no restrictions on their commerce, and the interior became exposed to epidemic invasion through these otherwise unimportant places. Other ports had only a nominal quarantine, because the revenue from fees was insufficient to defray the expenses of its management. Generally, however, there was some kind of quarantine regulations, but in few instances, save at certain large commercial centres, were they efficiently carried out. The value of quarantine became assailed on account of the inefficiency of its administration, and the opposition was for a long time strengthened by conflicting views concerning the origin of yellow fever. During the epidemic in Philadelphia, in 1793, the doctrine of its indigenous origin was advanced for the first time, and since then this has repeatedly been brought forward as an argument against quarantine restrictions. The extended experience of recent years has, however, apparently settled this question. Most of the epidemics have been traced to imported infection, although in a few instances, as at Newbern, in 1864, and Savannah, in 1876, the indigenous origin of the fever has been strongly urged. Moreover, the meteorological and local hygienic conditions of Southern cities during periods of freedom from disease have not differed essentially from those presented by epidemic periods. There are, therefore, few sanitary officers to-day who do not regard this fever as an exotic which may be excluded by suitable quarantine measures, but which, in the event of its introduction, may, under favorable protective conditions, survive the winter on the Gulf coast and reappear during the following summer without a fresh importation.

But although defective in their administration, so far as concerned protection, the seaport quarantines seldom failed to gather a tax from incoming vessels under the form of quarantine dues. Indeed, in some instances quarantine resolved itself into the collection of this tax in return for the official papers necessary to free pratique. According to Dr. Brown, "There is a great deal in the various laws about inspections of log-books, manifests, and bills of health; mustering of passengers and crew; examination of masters and others under oath; but practically all these requirements are seldom enforced. What actually takes place is for the health-officer to come on board as soon as the vessel heaves to off the quarantine ground, hurry to the captain's or purser's office, and, if she come from a non-infected port, simply inquire if all

are well on board, receive his fee, and depart as soon as possible. If from an infected port, he directs the master to bring his ship to anchor, and does not concern himself further about her unless she have sickness on board. During his brief stay on board, the steward of the ship is generally engaged in loading the health-officer's boat with fruit, ice, or other delicacies, which are received as a matter of course; and, indeed, any omission in this particular has been known to subject certain lines to great inconvenience. Lest this may be thought an exaggeration, I may mention that the health-officer of one of the Southern ports told me, some years ago, that he saved all his salary, as he was entirely supported by the great variety of articles he received in this way. As at present administered, the visits of inspection are simply a farce, the only object being to collect the fee and receive the *douceurs* which are the perquisites of the health-officer."

Quarantine fees at some of the Southern ports, particularly those of Texas, yielded a considerable revenue, and were a corresponding burden to the commercial interests. The States, according to Justice Bradley, "have a right to establish quarantine regulations for the protection of the public health, but they have no right to place toll-gatherers at the gateways of commerce and lay indiscriminate exactions upon all vessels that enter thereby." Even at the port of New York quarantine dues by far exceeded the necessities of the occasion, whereby the service and its officers became repeatedly subjected to adverse criticism.

In 1872, Dr. Harvey E. Brown, U.S.A., made a thorough inspection of the quarantines of the Southern ports exposed to invasion by yellow fever, in accordance with a joint resolution of Congress, providing for a more effective system of quarantine on the Southern and Gulf coasts. In his report this officer stated that these quarantines, being established by State or municipal authority, lacked that uniformity which is absolutely necessary to their efficiency, were not founded on rational views of the pathology of the disease, and were generally defective in their administration. To remedy the evil he recommended the assumption of quarantine by the General Government, and its administration by the War Department; claiming that only in this department of the Government is found that freedom from political influences and that authoritative management which demands absolute obedience to law, while granting the largest liberty to the individual consistent with the public safety. The Surgeon-General, in forwarding this report, did not endorse its recommendation for the transfer of quarantine duties to the medical corps of the army, as he conceived that the imposition of these responsibilities would materially interfere with the interests of the military service.

As the result of this investigation, a bill for a national quarantine passed the House of Representatives at its next session, but failed in the Senate. This bill proposed the institution of a quarantine board consisting of the Surgeon-Generals of the Army, Navy, and Marine Hospital Service, to formulate regulations which should not conflict with existing State regulations—these to be enforced by a quarantine officer specially detailed from one of the services. Its failure was ascribed to the manifest difficulty of making effective national regulations without interfering with the inharmonious requirements of the laws of the various States.

In 1878 a bill was passed by both houses of Congress empowering the Surgeon-General of the Marine Hospital Service to frame rules and regulations for the purpose of preventing the introduction of contagious diseases into the United States, which rules and regulations should be subject to the approval of the President, but should not conflict with or impair any sanitary or quarantine laws or regulations of any State or municipal authority which then existed or might thereafter be enacted. One of the orders published under the authority of this act prohibited from entering any port of the United States all vessels from the Black Sea or Sea of Azof conveying rags, furs, skins, hair, feathers boxed or baled, clothing or bedding, or any similar articles liable to convey infection, and all vessels from the Red Sea or Mediterranean having on board such articles coming from Southern Russia. This aroused a storm of opposition on the part of the commercial interests. Nearly one thousand paper-mills were affected by the enforcement of the order, and their influence, thrown in the balance against the act, was mainly instrumental in modifying subsequent legislation. On the other hand, the American Public Health Association had for several years been considering and urging the advisability of Federal protection against the introduction of foreign pestilences. The yellow-fever epidemic of 1878 brought to the support of this association many able men who had witnessed the misery, panic, and complete cessation of business relations which had overtaken the Southern States during the summer of that year. Several bills were brought before Congress, all looking to uniform quarantine regulations under national supervision. One which appointed a director-general of health, charged with the duties of declaring quarantine at his own discretion in any part of the United States, and making and enforcing quarantine regulations, was lost in committee. Another, which appointed a board of health to frame the regulations, and a director-general to enforce them at any port where the local health-officer failed to execute them, was passed by the Senate, but was viewed unfavorably by the House of Representatives.

Ultimately, in March, 1879, an act was passed authorizing a National Board of Health, consisting of seven members, to be appointed by the President, not more than one of whom was to be from any one State, and four national representatives, detailed respectively from the Attorney-General's Department and the Medical Departments of the Army, Navy, and Marine Hospital Service. This board was required to obtain information on all matters affecting the public health, to advise the several departments of the Government, the executives of the several States, and the commissioners of the District of Columbia on all questions submitted by them, or whenever in the opinion of the board such advice would tend to the preservation and improvement of the public health; and in the discharge of these duties it was authorized to make or cause to be made such special examinations and investigations, at any place or places within the United States or at any foreign port, as it deemed necessary. It was also required to mature and report to Congress a plan for a national public health organization, the principal sanitary organizations and the sanitarians of the several States to be consulted in its preparation, with reference specially to quarantine, maritime and inland, and to the regulations which should be established between State or local quarantines and a national quarantine system. But before action was taken on this requirement the law of June 2, 1879, was enacted, imposing on the board certain duties in connection with quarantine. These were immediately undertaken, and the measures adopted were subsequently approved by the Academy of Sciences and the American Public Health Association, which advised against any change in the organization or methods. The board was required to make such rules and regulations as are authorized by the laws of the United States and necessary, for sanitary reasons, to be observed by vessels at their port of departure and on the voyage, when contagious or infectious disease was present at the said port; these rules, after approval by the President, to be published, communicated to, and enforced by the consular officers of the United States. As afterward framed, they required the exclusion from the vessel, as far as possible, of persons or things known or suspected to be infected; cleanliness, ventilation, and disinfection, if needful, preliminary to loading; and a sanitary or medical inspection prior to sailing, with the certification of the consular officer or medical officer of the consulate in the form of a bill of health. Vessels entering or attempting to enter any port of the United States without this bill of health, to show that they had in all respects complied with the requirements of the act, were to be subject to a fine not exceeding one thousand dollars. On its face this bill appeared to give the board a power over the sanitary condition of vessels coming to this country from in-

fected ports, by imposing a heavy penalty for the infringement of its rules; but a proviso, the effect of which was unforeseen, deprived the penalty clause of its force. To prevent the unwitting contravention of the law, it was provided that the penalty should not attach to any vessel until the act and the rules and regulations made in accordance with its requirements had been promulgated for at least ten days in the port of her departure. Under existing conditions of international comity, this promulgation of a United States law could not be effected at foreign ports, and but for the energy of our consular officers the intent of the law would have utterly failed. As it was, these officers at infected ports labored zealously to have all vessels clearing for the United States free from infection and in good sanitary condition. They had no support in their efforts, for vessels which had not complied with the law, as regards inspection and consular bills of health, very frequently found as ready admission into our ports, in the absence of infectious disease during the voyage, as those which had fulfilled the requirements of the law. Local quarantine authorities, if satisfied that the vessel was not a dangerous subject, permitted her to enter without reference to bills of health or other points connected with a national quarantine service. Nevertheless, much good was accomplished; for instance, the risk of importing yellow fever from Havana was much reduced by consular medical supervision over vessels sailing from that port, which supervision, although non-compulsory in character, was generally effected; and in the exceptional cases in which masters of vessels declined inspection, the quarantine authorities of the port of destination were notified by telegraph, and prepared to make special inquiry into the sanitary condition of such vessels.

Another section of the act under consideration required the board to co-operate with and aid State and municipal authorities in the execution of their rules and regulations, and authorized it to take steps toward strengthening the quarantine of ports at which existing regulations did not appear to give adequate protection. If there were no local regulations, or if these were defective, at any port, the board was called upon to report the facts to the President, who was authorized, at his discretion, to order the board to make rules and regulations for the port in question, to be enforced by the State authorities; but if the State authorities failed or declined to enforce them, the President was empowered to detail an officer or appoint a proper person for that purpose. Under this call to co-operate with and aid State and local boards, and in the exercise of the advisory duties imposed by its constituting act, the board, after full consultation with local health authorities and the sanitarians and commercial men of the country, drew up a system of quarantine rules, which it recommended for adoption at the various ports, and which were adopted by nearly all the local authorities, thus overcoming the difficulty of formulating rules which should not conflict with local laws. These rules recognized as contagious or infectious diseases, cholera, yellow fever, plague, small-pox, and typhus; as an infected port, one at which cholera, yellow fever, or plague exists, or at which small-pox or typhus prevails as an epidemic; and made use of the word quarantine as meaning *the administration employed to determine the presence or absence of the causes of contagious or infectious diseases in vessels arriving at a port, and to secure, if present, the removal or destruction of such causes.* They prescribed the accommodations and equipment of a quarantine station, and the general principles of detention for observation in the case of suspected vessels, and for medical and sanitary treatment in the case of infected vessels. Persons under observation for yellow fever were to be detained until, in the judgment of the local authority, they might be safely permitted to go on shore, but this period was in no case to be less than five days from the time of the last exposure. The period of incubation of the disease or diseases for which the ship was quarantined was to be held in view in considering the duration of the detention of persons who had been, or were supposed to have been, exposed to infection.

Also, in aid of the local authorities, certain refuge stations for infected vessels were established on the coast. One for ports on the Gulf coast at Ship Island, Miss., a second for the Southern ports on the Atlantic coast at Sapelo Sound, Ga., and a third in Hampton Roads. Under the law these were not national quarantine stations, but lazarets or refuges for suspected or infected vessels refused admission by the local authorities of ports which had no facilities for the accommodation of suspects, the treatment of sick, and the proper handling of infected ships and cargoes. These stations were of immense advantage to the coasts which they covered, each acting as a local lazaret for the many small ports which were incapable of supporting an institution of that character, rendering unnecessary a multiplication of infected foci, and affording, under national auspices, better care to the stricken vessels than had been available prior to their establishment. The principle was by no means new. The English quarantine law, as has been seen, required all infected vessels approaching the coast of the United Kingdom to proceed to the thoroughly equipped station at Milford Haven; and in this country the quarantine establishment of the port of New York had always been open to vessels bound for the ports of New Jersey and Connecticut, and the Boston station to vessels for other New England ports. But the system was peculiarly suited to the needs of this country, in view of the relations of the National and State governments with respect to quarantine, the latter wielding the power under the law, and the former restricted to aid and co-operation. The local authorities of ports within the range of the refuges were enabled to operate efficiently in the exercise of their quarantine powers, by concentrating their resources on the management of a service of inspection and observation which granted admission to port or sent the vessel to the national refuge station, as might be deemed best under the circumstances.

It was the intention of the board to establish refuge stations at certain points from Galveston to the Delaware Breakwater, that the whole line of coast might have readily available support. Each station was to be provided with places for loading, detaining, cleansing, and disinfecting vessels; hospital accommodations for the sick, and quarters for passengers and crews held under observation; wharves, warehouses, and fumigating houses for the handling of infected cargoes; steam-tugs, boats, etc., for the proper administration of the station; medical supervision and attendance, and the personnel needful to carry out the purposes of the establishment, with quarters for their accommodation. But these intentions were frustrated by the action of Congress in locking up the unexpended balance of the fund originally appropriated for such purposes. This appears to have been done under a misapprehension of the character of the proposed stations, which were at the time frequently spoken of as national quarantine stations, and must be construed as an expression of the disinclination of Congress to warrant national interference with State and local authority. The station established at Ship Island, Miss., for co-operation with the Gulf ports, was well outfitted with pavilion quarters and hospital, wharves, storehouses, boats, a steam-tug for boarding vessels, and a sloop for communication with the mainland. The Sapelo Sound station was in efficient working order, and gave much satisfaction to the quarantine authorities of Georgia and South Carolina, although much of its accommodation was of a rude and makeshift character. At Norfolk a barge was fitted up as a floating hospital for the relief of any infected vessel that might put into Hampton Roads for assistance.

The board was also required to co-operate with and aid State and local authorities in preventing the spread of epidemic disease from one State into another, and very shortly after its organization the Memphis epidemic called forth every energy for its limitation. During the epidemic of the previous year, 1878, self-preservation imposed the policy of non-intercourse on most of the Southern communities, and what was known as the shotgun quarantine was inaugurated: Vessels from New Orleans or other infected or suspected places were repelled from

the Mississippi landings by armed citizens, and trains and other overland modes of interstate communication were stopped at the State line and denied right of way. But under the auspices of the National Board of Health these rigorous quarantines were replaced by the system of medical inspection; commerce and travel were not interrupted, but placed under such a supervision that the disease was not propagated on their lines. According to the report of a Senate committee of the Forty-seventh Congress, the disease "was actually stamped out in New Orleans and confined to the limits of Memphis; and instead of the general disorganization and panic, with suspension of business, trade, and commerce which pervaded the country in 1878, commerce and communication with the infected cities were *regulated—not stopped*, or even retarded to any considerable extent—and the general business of the country went on in its usual methods and through its usual channels without serious interruption. Instead of panic and alarm, confidence and a sense of security pervaded the country." This system proved so efficient in restraining the spread of yellow fever, that in the following year its continuance was imposed on the board by the action of the States that were exposed to danger from the presence of the disease in New Orleans. As this city had been the starting-point for many wide-spread epidemics, its condition was narrowly watched by the health authorities of neighboring States, and on the acknowledgment of the presence of suspicious cases ordinances were passed prohibiting the landing of freight or passengers within their jurisdiction, unless these carried with them the inspection certificates of the national health service. At first the official announcement of the resident member of the National Board was accepted by the States as authoritative with regard to the condition of New Orleans; but as it was found that the city authorities were disposed to withhold information in suspicious cases, the mere rumor of a case of fever sometimes precipitated the action of the States in their demand for National Health Board inspections as a guarantee of safety. New Orleans acknowledged the advantage of these inspections in permitting commercial intercourse which would otherwise have been stopped during the existence of fever, but objected to the imposition of any restriction, delay, or inconvenience until the disease was acknowledged by its own authorities. The desire to suppress all suspicion of infectious disease in its line of operations is as old as commerce itself. De Foe, speaking of the last and greatest epidemic of plague in London, says that, early in May (1665), it "had gotten into several streets, and several families lay all sick together, and accordingly in the next weekly bill the thing began to show itself; there was, indeed, but fourteen set down for the plague, but this was all knavery and collusion, for St. Giles parish buried forty in all, most of whom it was certain died of the plague." The Mississippi States did not have that confidence in the official statements of the health authorities of the city of New Orleans that they were ready to give to the National Board of Health, which represented their interests in the suspected city. During the continuance of yellow fever in the city every vessel, with its crew, passengers, and cargo was inspected before sailing, and similar precautions were taken on the lines of rail. Refuge stations were established at points on the river below Memphis, Tenn., and Vicksburg, Miss.; at Cairo, Ill., and Bayou Sara, La., at which vessels were inspected in passing and their bills of health *viséd* for free admission into their port of destination, or detained for appropriate treatment if yellow fever was found to have been developed during the voyage.

The law which imposed on the National Board of Health the duty of aiding and co-operating with State and local authorities expired at the end of four years from its passage. It was tried as an experiment, but although successful, certain influences were at work to prevent its perpetuation. Chief among these was the desire of the Marine Hospital Service to erect itself into a bureau of medical officers of the Treasury Department similar to that of the Army or Navy. The law of 1878, repealed in 1879, placed the so-called national quarantine in the hands of this service, and from that time it has made every effort to recover its lost position and constitute its members federal quarantine officers, paid from the national treasury, instead of hired medical attendants, paid for their services to sick sailors from a fund contributed by the mercantile marine. The board was represented as merely a medium by which State and local authorities dipped their hands into the federal treasury, and the antagonism of the New Orleans board was magnified into inability to co-operate with the local sanitary authorities of the country; while the Marine Hospital Service was upheld as having a medical staff, hospitals, revenue cutters, etc., all of which could be used for quarantine purposes without calling into existence any new machinery such as a National Board of Health. These arguments, shallow as they were, sufficed to prevent the re-enactment of the so-called quarantine law, yet failed to carry congressional action so far as to make the Treasury Department the administrator of a national quarantine. The expedient was adopted of placing an epidemic fund in the hands of the President, to be used in aid of State and local boards of health, or otherwise at his discretion, in preventing and suppressing epidemics and maintaining quarantine at points of danger. The disposition of this fund has been transferred to the Treasury Department, and of late years the current expenses of the refuge stations established by the National Board of Health have been paid from it by the Marine Hospital Service.

Other than the law passed at the end of the last century, requiring revenue, marine, and custom officials to aid in the enforcement of local laws, and an appropriation in the sundry civil bill of each successive year, to be used in case of an epidemic, there is at present no national legislation for the protection of the country from invasion by exotic disease. Several efforts have been made by State and local boards, and such sanitary organizations as the American Public Health Association, and the Sanitary Council of the Mississippi Valley, for the rehabilitation of the National Board of Health; but these have failed, and the country is now in no better condition as regards national legislation than it was during the epidemic of 1798, which devastated Philadelphia and New York, and prevailed even in Boston and other New England towns.

The need of a central health organization as a bond of union between the State authorities, and a means for co-ordinating their action and representing their interests on the international aspect in the case of a threatened invasion of cholera or yellow fever, has been so well appreciated by these authorities, that, having failed through the opposition of the Treasury in their efforts to secure the re-establishment of the National Board of Health, they endeavored to obtain from Congress a central health authority of some kind, urging at first a board constituted by State representation, and when that was declined on the ground of unwieldiness, asking with equally negative results for a director-general of health; yet ready to be satisfied with any legislation that would enable them to realize the benefits of co-operative action such as were obtained under the auspices of the National Board of Health. Meanwhile this board continues to have a legal existence, as the limitation of four years applied only to the so-called quarantine law, not to the constitution of the board. It requires merely the financial support of Congress to enable it to resume the labor of amalgamating into a trustworthy whole the inspection or quarantine systems that protect the coast, and the salient points of interstate travel and traffic.

Charles Smart.

QUASSIA, U. S. Ph.; *Quassiæ Lignum*, Br. Ph.; *Quassia de la Jamaïque*, Codex Med.; *Lignum Quassiæ*, Ph. G. (including also wood of *Q. amara*). The wood of *Picræna excelsa* Lindley; order, *Simarubaceæ*. A large, fine-looking tree, with erect, thick trunk and spreading branches covered with a rather smooth brownish-gray bark. Leaves alternate, odd-pinnate, leaflets entire, oblong, pointed, thick, and smooth. Flowers

small, in lateral cymes, polygamous, greenish-yellow. The perfect ones have a calyx of five minute teeth, five petals, five stamens about as long as the corolla, and two or three one-ovuled carpels with their styles united. The staminate flowers have more spreading petals and longer stamens, no pistils. The carpels ripen into purplish-black drupes. Jamaica Quassia, also called Bitter Wood or Bitter Ash, from its resemblance to that tree, is a native of some of the West India islands, from several of which the wood is exported, especially from Jamaica.

Originally the name was applied to the wood of *Quassia amara* (*Bois amer de Surinam*, Codex Med.), a shrub belonging in the same family and possessing exactly the same qualities, growing in Central and South America, and first introduced into Europe about the middle of the last century. The present tree was generally substituted for *Q. amara* in the early part of this century, although the other is still found in European pharmacies. *Q. amara* is rarely to be found in American or English shops.

FIG. 3226.—Flowering Branch of Quassia (Picræna excelsa). (Baillon.)

Quassia is imported in billets or logs several feet long, and from two to six inches in diameter. It has a dark-gray bark, and tough, compact, yellowish-white, inodorous, but very bitter, wood. These logs generally go to turners, where the best are cut into drinking-cups or goblets, and the pieces are saved for the pharmacies. Otherwise the logs must be cut or rasped into fine pieces to make them suitable for pharmaceutical handling. These shavings are yellow, inodorous, and intensely and persistently bitter.

COMPOSITION.—The bitterness of Quassia is due to a minute quantity of a neutral crystalline substance, first obtained in 1835 by Winckler from the wood of *Q. amara*, and afterward from that of the Picræna now used. *Quassiin* is sparingly soluble in water and alcohol, has an exceedingly bitter taste, and probably represents the tonic and "narcotic" properties of the crude drug. Quassia contains no tannin.

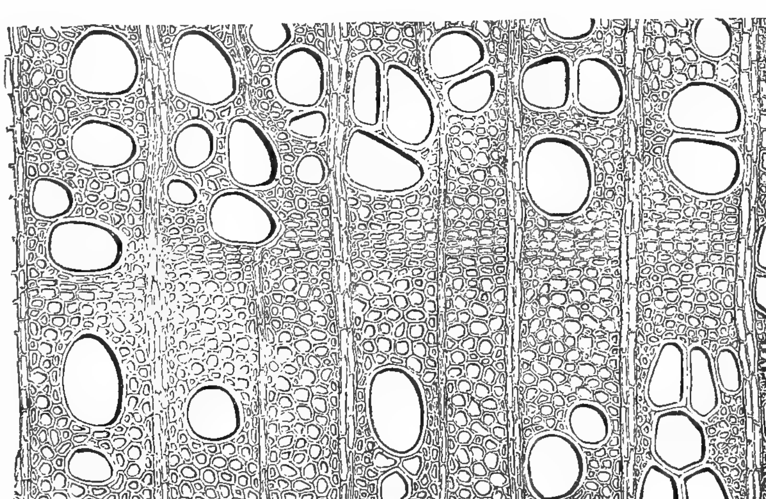

FIG. 3227.—Section of Quassia Wood. (Baillon.)

ACTION AND USE.—Quassia is generally regarded as a pure or simple bitter tonic, like gentian, and is mostly used as such, being given, either alone or in combination with aromatics and stimulants, as a stomachic and appetizer. In debility, in convalescence from fevers, in dyspepsia, it has been and is still in considerable use. Its taste is, however, more bitter and disagreeable than that of gentian or quinine, and on this account alone would be less desirable as an appetizer than they. Quassia is, in addition, poisonous to insects and fishes, and probably in a slight degree to other animals. The symptoms produced by it are stupor, convulsions, paralysis, etc. It does not appear to be deleterious to man. Another useful employment of the drug, depending upon this insecticide or vermicide power, is as an injection for ascarides, for which purpose it is both safe and efficient.

ADMINISTRATION.—Dose: One or two grams (gr. xv. ad xxx.) in infusion. The officinal preparations are Tincture (*Tinctura Quassiæ*, U. S. Ph., $\frac{1}{10}$), Fluid Extract (*Extractum Quassiæ Fluidum*, U. S. Ph., $\frac{1}{1}$), and Extract (*Extractum Quassiæ*, about $\frac{30}{1}$); the latter is useful for administration as pills. The "Quassia cups" are medical toys of no great value. For injection as a vermicide from half a pint to a pint of a ten per cent. infusion may be used.

ALLIED PLANTS.—Besides three species of *Picræna*, all bitter, the order contains *Quassia amara*, above noted; *Q. cedron* H. Br., and *Simaruba officinalis* D. C., both of which contain the same bitter principles and are in the Codex. It also contains the *Ailanthus glandulosa* Desf.

ALLIED DRUGS.—For tonics see GENTIAN, for anthelmintics see KOOSSO. *W. P. Bolles.*

QUEBRACHO. This name is given in portions of Central and South America to several different trees whose wood or bark is mostly used in tanning; of these that known as white or pale Quebracho (*Quebracho blanco*), is the only one of special medical interest. It is *Aspidosperma Quebracho* Schlecht., order, *Apocynaceæ*, and is also used in tanning. It is a large-sized tree, with slender, drooping twigs; small, opposite, or whorled (in threes), short-petioled or sessile, elliptic-lanceolate, pointed, leathery, bluish-green leaves; numerous axillary clusters of small yellow flowers, and large elliptical, woody capsules (Lüerssen). It is an inhabitant of tropical South America; the bark is exported from Brazil, where it is valued as an antiperiodic.

Quebracho was first brought to medical notice in Eu-

rope, about ten years ago, by Dr. Penzoldt, as a cure for asthma. The bark, which is the portion employed, comes in thick, coarse pieces, of a yellowish-brown color, and bitter taste. It contains an abundance of *tannin*, and six alkaloids: *Aspidospermine*, crystallizing in needles, soluble in about fifty parts of alcohol, one hundred of ether, and six thousand of water—a weak base of bitter taste; *Aspidospermatine*, in warty crystals, more soluble; *Aspidosamine*, amorphous or partly crystalline; *Quebrachine*, colorless crystals becoming yellow in the light; *Hypoquebrachine*, yellow albuminoid masses; *Quebrachomine*, resembling quebrachine. These alkaloids all weaken respiration and circulation, and most of them are general paralyzers of motion. All nauseate somewhat; aspidosamine is decidedly emetic; quebrachine is most efficient in its effect upon the breathing; *aspidospermine* is similar, but weaker. Quebracho, and the two last-named alkaloids, have been employed to reduce the dyspnœa of asthma, cardiac disease, phthisis, etc., with some reputed success; but although considerably tried and advertised several years ago, they are almost never called for at present; they appear to have done the most good in asthma. Dose, two or three grams (gr. xxx. ad xlv.), in form of tincture or infusion; of the alkaloids quebrachine or aspidospermine from two to three centigrams may be given.

Allied Plants.—The genus *Aspidosperma* contains upward of forty species, mostly South American. The order is not an important one; it contains a few, not valuable medicinal, and some poisonous, plants. *Alstonia scholaris*, etc., the *Apocynums*, *Strophanthus*, *Nerium*, and *Vinca*, are examples.

Allied Drugs.—Morphine is probably more reliable as a respiratory depressant, and has also a great advantage over quebracho of stilling pain besides.

W. P. Bolles.

QUEEN'S ROOT (*Stillingia*, U. S. Ph.). The root of *Stillingia sylvatica* Linn., order, *Euphorbiaceæ*, a perennial plant, with a large, woody root, and erect herbaceous or slightly woody stem, a foot or so in height; leaves large, thick, oval, or lanceolate, finely serrate; inflorescence a thick terminal spike. Flowers unisexual, the female, few at the base of the spike, solitary, each in the axil of a thin, broad scale, with a large gland at each side, consist of a three-lobed calyx, three-celled ovary, and three styles; the staminate flowers are numerous, clustered in the axils of similar bracts all the way up the axis; they consist of a minute cup, from which emerge two partly united stamens. Stillingia grows abundantly in the Southern States, and has been used there, and a little elsewhere, for about half a century.

The root is "about twelve inches (30 centimetres) long, and nearly two inches (5 centimetres) thick, subcylindrical, slightly branched, compact, wrinkled, tough, grayish-brown, breaking with a fibrous fracture, showing a thick bark and porous wood: the inner bark and medullary rays with numerous yellowish-brown resin-cells; odor peculiar, unpleasant; taste bitter, acrid" (U. S. Ph.). The composition of stillingia is not well known; *essential* oil and *resin* appear to be present. It is an emeto-cathartic, like many other plants in the order, and is also said to be "alterative." Upon this property its principal use depends. It is considerably used in "scrofula," late syphilis, and other chronic complaints, with reputed benefit. Dose, one or two grams (gr. xv. ad xxx.) two or three times a day. A fluid extract is officinal (*Extractum Stillingiæ Fluidum*, U. S. Ph.).

Allied Plants.—Another species of *Stillingia* yields the Chinese "vegetable tallow." For the order see Castor-oil.

Allied Drugs.—Sarsaparilla *et id omne genus;* Poke Root, Bitter-sweet, etc. *W. P. Bolles.*

QUINCE SEED (*Cydonium*, U. S. Ph.; *Coing*, Codex Med.). The seed of the garden quince—*Cydonia vulgaris* Persoon—order, *Rosaceæ*, an Asiatic shrub cultivated in Europe for many centuries, and now grown in most warm, temperate countries. The fruits contain

malic acid, *pectin*, *mucilage*, etc., and have a peculiar flavor, due, perhaps, to *pelargonic ether*. The seeds are valued for their *mucilage*, and have been long in use in Eastern countries. They also contain a trace of *hydrocyanic acid*. Quince seeds grow eight, ten, or more in each cell—they are smaller and more irregular in shape than apple seeds—have a dull surface, and are agglutinated together. They contain about twenty per cent. of a pe-

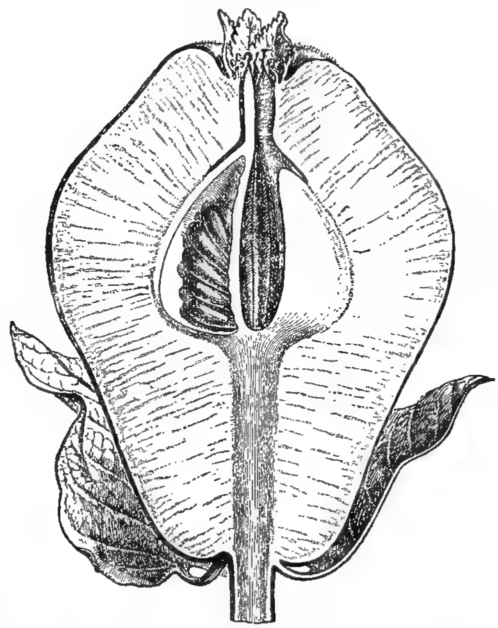

Fig. 3223.—Garden Quince: Section of Fruit. (Baillon.)

culiar mucilage, capable of gelatinizing more than one hundred parts of water, but of little adhesive power; it consists of a soluble acacia-like portion, and an insoluble part having many of the characteristics of cellulose. The officinal mucilage is made with two per cent. of seeds. Quince seed may be put to the various uses of mucilages in general, demulcent drinks, *collyria*, surgical dressings, sizing, etc.

The principal demand for it, within the past few years, has been for toilet purposes (dressing the hair).

Allied Plants.—See Roses.

Allied Drugs.—See Gum Arabic. *W. P. Bolles.*

QUINTO is a spa in the province of Saragossa, Spain. There are two springs, of similar composition, the waters of which are employed, as a rule, only internally. The two springs are known as the Upper and the Lower. The following is the composition of Quinto water, according to the analyses of Moreno and Lletget, quoted by Rotureau in the "Dictionnaire Encyclopédique des Sciences Médicales."

One litre contains:

	Grammes.
Calcium sulphate	1.759
Sodium sulphate	0.498
Magnesium sulphate	0.307
Magnesium chloride	0.014
Sodium chloride	0.009
Calcium chloride	0.005
Silicic acid	0.010
Total	2.602

These waters enjoy considerable reputation in Spain in the treatment of syphilitic affections. They are also employed in digestive troubles and for the relief of those suffering from uric-acid gravel. The waters are both diuretic and laxative. The season extends from the first of June to the end of September. *T. L. S.*

RABIES. (Gr., Lyssa; Lat., Rabies; Germ., Hundswuth, Tollwuth; Fr., Rage, Hydrophobie.) Rabies, or, as it is more commonly designated in our language, hydrophobia, is to be classed essentially among the more pronounced neuroses. It is thought to be occasioned only by the specific poison from rabic animals, and its principal phenomena are connected with an exalted reflex irritability, chiefly of the respiratory nervous centre, and the centre of deglutition; later, there are increased irritability of the motor spinal centres, general hyperæsthesia, and, finally, psychical exaltation. Lyssa is therefore to be regarded, from its symptomatic characteristics, as a specific toxic affection, and is essentially a variety of tetanus, similar in some degree to that caused by strychnia. It is placed in the list of those diseases which, for want of a better classification, may be called "tetanici."

Rabies seems to belong to the same class of diseases as erysipelas, anthrax, etc., in that it depends for its transmission upon inoculation into the blood, or at least into the subcutaneous tissues of the animal body. It presents many points of similarity with many of the bacterial forms of disease, in which the infecting agent is known to invade the body, and there multiply, and by its increase to produce the phenomena of the disease.

True rabies (lyssa vera) arises in all instances from infection by the specific virus, or that material substance which contains or conveys the infecting principle, as produced in animals affected with this malady.

Rabies in man is not known to have ever occurred except after penetration of the rabic poison beneath the epidermis, or other epithelial covering of the body. There is no known case in which it has been actually proved that infection has taken place through the uninjured mucous membrane, although cases have been reported in which this has been thought to occur. These cases are either due to a mistake in diagnosis, or to the fact that slight lesions of the mucous membranes are easily overlooked, or may be quite healed before the disease makes itself evident.

As a proof of the protection afforded by the mucous membrane against the entrance of the rabic virus into the animal system, is the fact that the flesh and milk of animals affected with this disease have been used as food by the human subject without the slightest ill effects. This fact accords with the further fact, that the milk and butter from cows which are the subjects of rabies may be taken with impunity.

The sole avenue of entrance of the rabic poison is, therefore, by the path of infection, and this means the inoculation of the disease.

Rabic infection may take place in various ways: First, from the teeth or the bite of a diseased animal. This is not dangerous unless the teeth have penetrated the epidermis, or at least have eroded or abraded it, and by this means a path of entrance has been made for the saliva to reach the subcutaneous tissues. There is reason to believe that the virus is dangerous at a period somewhat previous to the development of the marked signs of rabies in the dog. The danger is proportionally increased as the teeth of the dog are sharp, and the wound is deep and penetrates the flesh to a greater degree.

The power of communicating the disease is not confined to the periods of fury, which are a feature of the malady in the dog, but the rabic animal is prone to become suddenly furious from a state of absolute quiet, in which the existence of a serious disease could not be suspected, and may then inflict a fatal bite.

The clothing, or other covering of the body, affords a limited degree of protection from the poison of rabies, as the passage of the teeth of an animal through the clothes removes the saliva to a more or less perfect degree.

The claws of any of the carnivorous animals may be the bearers of the rabic poison, from the fact that they are more or less in contact with the mouth of the animal, and are likely to become contaminated with the saliva. A slight scratch would be sufficient to afford entrance to the infection. The disease may also be communicated by the tongue of the rabid animal, in licking any place from which the epithelium is absent, which thus allows the virus to come into contact with the subcutaneous tissues.

Second. Another source of danger is the flesh or blood of animals dead from rabies, which constitutes a peril to those who may be employed in the disposal of the bodies, or in making post-mortem examination, of such animals. The smallest excoriation or abrasion is sufficient for the infection of the system, and thus for the introduction of a fatal disease.

Etiology.—The etiology of rabies (lyssa humana) is uniformly and invariably the inoculation of the system with the specific poison of the disease, derived from an infected animal—dog, cat, fox, wolf, horse, skunk, cayote, the ruminants, swine; and in one case observed by the writer, the disease followed the bite of a rabbit, which was not known to be affected. It is not definitely known that other species of animals are capable of communicating the infection of rabies.

Like anthrax and many other infective disorders, the inoculation by rabies always takes place through some wound or other defect of the skin or mucous membrane; and the disease is communicable only by means of introduction of the virus into the subcutaneous tissues. The virus is contained not only in the saliva of diseased animals, but also in other glandular secretions, in the blood, in the substance of the nervous structures, and probably in all the tissues of the body.

Rabies is uniformly dependent upon infection from without, and in nearly all cases the disease is communicated by means of the bite of a rabid animal. The period of incubation of this disease, *i.e.*, the length of time after the introduction of the virus into the system before the symptoms of rabies make their appearance, is a variable one. It has been known to become evident within the first day after inoculation, and it is sometimes delayed in its appearance for months, or even years. The most frequent period for the invasion of the disease is at a time from three to eight weeks after inoculation.

There appears to exist in rabies, as in syphilis, a period of latence of the infectious material, during which it may be retained within the system, but shows no symptoms of its presence. At times the disease appears to cause prodromal symptoms in the original seat of the infection, such as pain, swelling, etc., with restlessness and anxiety on the part of the patient; but often the malady appears suddenly in the form of well-marked disturbance in swallowing, or the initial symptom may be a convulsion of the respiratory apparatus following an attempt at swallowing. Death is usually inevitable, generally occurring between three and six days after the first onset of the symptoms of the disease. The fatal result may even occur in so short a time as twelve to twenty-four hours. The temperature of the body is elevated, at times reaching 40° C. (104° F.). Death follows from apoplexy, asphyxia, exhaustion, or the patient dies suddenly from some unknown interference with the vital processes. Not all patients who are bitten by rabid dogs are attacked by rabies; the predisposition of the patient to infection of any kind has much to do with the severity of the symptoms in many cases. The most important features of any case are the location, and still more the depth, of the bite. Lacerations by the teeth of the rabid animal, which are situated upon unprotected parts, and especially those which penetrate deeply, are most dangerous.

Incubation.—The dreaded character of the rabic disease, and the great variability which exists in regard to the time of its appearance after the poison has entered the system, have led to the more careful obervation of cases in which there was supposed to be danger of this malady, with the result of obtaining more definite and uniform information as to the time and the manner of the symptoms which usher in the rabic development. It has been noticed that local sensitiveness, with a gradual extension from the extremity toward the trunk, occasionally precedes the outbreak of the disease, accompanied by renewed pain in the scar of the bite, or in the bite itself, if this be not already healed, with redness and swelling of the neighborhood. Often there is prodromal rest-

lessness, with physical depression, febrile action, etc., though in some cases the spasm in deglutition is the first noticeable symptom of the invasion of the disease. Recently M. Pasteur, of Paris, has made all the known authentic cases of undoubted rabies which have occurred in France, the subject of careful analysis as to the period which elapsed after the inoculation of the disease, before the invasion of the symptoms of the fatal malady. He collected data concerning 537 cases. Of these, 27 were excluded from one cause or another, leaving 510 cases as the basis of his deductions.

These 510 cases show an average period of incubation of 72 days, which is divided among the cases in the following manner: In men the period of incubation was found to be 80 days on the average; in women it was, on the contrary, only 65 days. The period of latency in men is, therefore, 15 days longer than in women. In persons between the ages of two to fourteen years, the latent period was 20 days shorter than in persons between fifteen and seventy-eight years (women, 57 days; men, 76 to 77.5 days, respectively). This apparent difference may possibly be accounted for, in some degree, by the fact that in children the wounds produced by a rabid animal are more likely to be located upon the face or other uncovered parts of the body, and thus inoculation of the patients may take place more easily; and possibly the violence of the succeeding phenomena may also be thereby materially augmented.

It is found that in cases in which the injuries were seated upon the head and neck, the period of incubation was 55 days; while in those cases in which the wounds were situated upon the upper extremity it was 81, and on the lower extremity it was 74 days; while in such cases as presented injuries of many parts of the body, among which were wounds about the head, the period of incubation was 55 days.

Persons who have been bitten by rabid wolves, to the number of 49, presented a period of incubation of 39 days; those bitten by dogs, 293 cases, a period of 73.5 days; and those bitten by cats, 31 cases, a period of 80 days. Pasteur had already called attention to the shorter period of incubation in cases of inoculation from the bites of rabid wolves.

The period of incubation is not modified in any way by any mode of treatment, neither is the duration of the disease, when it is developed, in any material way modified by the longer or shorter period of latence of the poison in the system. It is found that in seventeen per cent. of all cases of rabies the period of incubation is three months or over.

Pasteur states that the disease shows itself, in the majority of cases, at a period between the fortieth and sixtieth days after the reception of the bite.

Diagnosis.—The most prominent symptoms of rabies are referable to the nervous system, and consist of an exaltation of the reflex irritability, especially of those departments which control the power of deglutition and the phenomena of respiration. These symptoms are soon followed by the development of an abnormal degree of nervous irritability of the spinal motor centres, by general hyperæsthesia of the entire body, and finally by pronounced mental and moral disturbances.

The classical and only indispensable symptom of human rabies consists in the frightful and recurrent spasm which is induced by attempts at deglutition, by the presence of saliva in the pharynx, by efforts at deep inspiration, as well as by the slightest irritation of the skin from any cause, and also by the movements of the atmosphere, in which the slightest breeze is caused, or at least felt, especially if the temperature of the external irritant or of the air be much below that of the body of the patient.

The fact that the attempt to swallow is productive of great distress, and that it induces the spasm, causes the utmost terror in the mind of the patient at the thought of deglutition. This induces the fear of fluids so characteristic of this disease. It is the pain and distress thus occasioned which constitute the real source of the "hydrophobia," the fear of the painful spasm of respiration and deglutition which the effort of swallowing induces.

The term "hydrophobia" is the origin of much needless confusion, for not only may a fear of the effort required to take liquids be present, without the existence of rabies, but the rabic disease may be developed in fatal intensity without the occurrence of the spasmodic symptoms usually associated with rabies. Hydrophobia alone does not constitute rabies, and rabies may exist without "hydrophobia." In fact, in canine rabies, the hydrophobia is not a prominent or a frequent symptom. We should understand by the term "hydrophobia" a condition which may be thus delineated: First, one in which, without apparent motive, the patient finds it impossible to swallow liquids, and which may or may not be accompanied by disagreeable or painful sensations to the patient; second, the sensation of fear or terror at the sight or sound of fluids, even when the patient may be able to overcome this feeling so as to take fluids voluntarily as drink. Patients with rabies are frequently found in a state of great excitement from the fact that the fatal character of this disease is well known, but the patient can always be restored to proper consciousness by kindly and calming efforts on the part of those about him. Hydrophobia, therefore, constitutes only a symptom common to several distinct diseases. It is the product of an abnormal excitation of the nervous centres, or the nervous elements, either of direct or of reflex origin; or it is due to the disturbance of the normal relations existing in the tissues, which may be of three varieties: 1, a disturbance of the nutrition of the member or part; 2, the effect of a direct irritant; and 3, the disturbance of the nervous supply, or of its distribution in the part affected.

The "hydrophobia" (fear of water or other fluid) is apparently due to an affection of the general nervous system, for the hydrophobic spasm is present before the patient attempts to drink; and it may be provoked by a variety of causes, such as a bright light, the view of an unexpected or unusual object, a sudden noise, a touch from an unfamiliar substance, or even the movements of those about the patient or the impression produced by a draught of air.

The last is one of the most important symptoms of true rabies (Lyssa vera), as it is never absent in the real disease, and is seldom present in any of the other affections which are associated with or accompanied by spasm of deglutition. It is indicative of communicated rabies.

The excessive tension or the exalted reflex irritability in the nervous centres, or in those nervous centres which are concerned in respiration, is the essential character of the rabic development in man. The augmentation of the excitement by the indispensable requirements of the animal (human) organism (air, water, etc.), and the discharge of nervous force in the way of powerful contraction of the muscles controlled by the nerves of respiration and of deglutition, constitute the symbols of the disease. These pathognomonic conditions constitute the means of distinguishing rabies from any other condition of the system which may be accompanied by hydrophobia (Jaccoud).

The terror, the maniacal fright, the convulsive cries, seem to be provoked by any agitation of external objects in a manner to impress any of the special senses. It would seem that the entire nervous system, the general sensibility, as well as the special senses, the intellectual faculties, and the moral nature are in a state of superexcitation, so that the least irritation of any part is communicated to the entire system by a kind of special reflex action, and produces the convulsive explosion.

There seems to exist a special hyperæsthesia, which does not manifest itself at the seat of contact, as is usual in such conditions, but which is reflected to remote centres, and there produces an explosion of force in the form of painful spasm, cramps, convulsive contortions, and delirium of varying intensity, often associated with cries, fury, terror, visions, hallucinations of the special senses, etc.

The symptoms of rabies are at times very confusing, and have given rise to the two designations, "hysterical hydrophobia" and "hydrophobic hysteria," both of which conditions undoubtedly exist, and render the diagnosis

of the actual state of the patient more or less difficult, and frequently prolong the period of uncertainty as to the precise nature of the malady. The exalted mental excitability of the patient exaggerates the already existing irritability, and the spasm is at length induced by the sight or the sound of fluids, and finally is aroused by the simple thought of liquids or of drinking. The anxiety of the patient is increased by the well-known fatal character of the malady, and is too often unnecessarily and cruelly augmented by the injudicious and senseless conduct of those about the patient; and in those cases in which the fear of the disease leads to the improper or brutal treatment of the sufferer, which has often occurred, there is frequently a condition of absolute mania. Calm and gentle measures will, however, always recall the patient to a consciousness of himself and his surroundings.

The diagnosis of rabies in the human subject may be rendered difficult or temporarily impossible from simulation of the disease by Lyssa falsa, seu nervosa. This is a condition which is frequently induced by the fear of rabies, and usually follows the innocent bite of an animal free from the disease. The diagnosis cannot long remain the subject of doubt, as an interval of a few days—never longer than six—will suffice in all cases to definitely establish or to disprove the existence of the disease.

Lyssa falsa may occasionally be followed by a fatal termination, owing to the anxiety of the patient, as has frequently been observed in neurotic individuals, after the bite of a healthy animal, and even after the accidental bite of the human subject in cases in which there could be no suspicion of rabies.

These rare cases may, perhaps, be classed as tetanus, or as tetanus traumaticus lyssoides, as has been suggested by Lorinser.

The result of rabies is invariably fatal, and usually occurs within three days after the appearance of the disease. Occasionally the life of the patient is prolonged until the fifth or sixth day, but this is exceptional. In the human being the first symptoms of the fatal attack seem to be a peculiar itching of the old wound, and the spread of neuralgic pains from it toward the nerve-centres. A general feeling of malaise, and an impending dread of something frightful about to happen, a tightness about the throat, are among the common complaints of the sufferer, and there is difficulty in swallowing; breathing becomes affected, and there is oppression over the whole chest. Violent paroxysms follow, showing evidently that the whole nervous system is in a frightfully excited state. A ray of light, a breath of wind on an exposed part of the body, the sight of water, the constriction following the attempt at swallowing any fluid, greatly craved though it may be, are sometimes sufficient to determine the spasm. Ropy, viscid mucus is secreted by the salivary glands, and vehemently expelled from the mouth. Violent convulsions of the muscles of the larynx and pharynx take place in many cases, closing the windpipe and preventing the access of air. Hallucinations come on, and sometimes wild delirium. During the interval between the attacks the sufferer is often calm and rational, and, in many cases, feeling the approaching access, he begs to be restrained so that he may do no harm. Paralysis finally supervenes, and the sufferer, totally exhausted, is mercifully relieved by death. The fatal result may occur in a short time (from twelve to thirty-six hours). In other cases the disease steadily advances to a severer form, the temperature rising to 40° C. (104° F.). Death usually takes place then from apoplexy, or from asphyxia, or the patient may suddenly expire, even when improvement may seemingly have occurred.

The following vivid description of the progress of human rabies is taken from the *Archives de Physiologie*, February 15, 1887. It is from the pen of M. J. Girode. The patient was treated in the Hôpital Beaujon, by M. Guyot. The case belongs to that form in which the symptoms are developed with great rapidity, and is classed as "presque foudroyante." The clinical history is as follows:

Henry B., twenty-eight years of age, Italian, entered the hospital April 10, 1886. He has always been well. His character is of an impressionable nature, and he is decidedly nervous. He has been unfortunate in his affairs, and has practised as a musician, an actor, and a model in a studio. Has used intoxicating liquors somewhat to excess. He had a small slut dog, which was of very gentle disposition, but which bit him on the right hand, some two months ago, in consequence of a slight punishment. He compressed the wounded fingers in order to encourage bleeding for the time being; but thought no more of the matter. On the same evening the dog became morose, remained crouched in a corner, and died in the space of three days, without having taken either food or drink. These events occurred between February 10th and 15th, 1886.

In spite of their very suspicious character no one thought of these symptoms as indicating any dangerous condition, either of the dog or of the wound made by the bite in the patient's hand.

Until April 9th the patient remained perfectly well and strong. On this date he awoke with a severe headache; went, however, to his daily occupation; was hardly able to take any food at dinner, but still continued his work. Toward two o'clock he began to feel weak and feeble. One of his companions offered him some drink, but he pushed the glass violently from him, and was for a few moments in a state of collapse, without, however, wholly losing consciousness. He went to his home about three o'clock on April 9th, remained there until the 10th, at four o'clock, at which time he presented the following symptoms: headache, absolute sleeplessness, with periods of great restlessness, noisy delirium, moderate flow of saliva, absolute inability to swallow either liquids or solids, an overpowering sensation of constriction of the neck, with brief periods of great irritability during which he refused to see his friends, who were endeavoring to calm him and to restrain him from leaving the bed.

On arrival at the hospital the patient was seen to be a remarkably strong and well-built man, tall, with powerfully developed muscles. The face was pale, the features animated, the eyes bright and moist, the eyelids widely opened at times, giving the facial picture a strange appearance which might almost be called terrifying. He was sitting on the bed, calm, and remained quiet while the examination of his condition was being made. The patient had entire control of himself, and the mind was clear. His replies were correct; his chief anxiety seemed to be that he should be relieved from suffering; he spoke frequently of his children and of his mother. In spite of his loquacity it was possible for him to remain still, and he could assume a reclining posture without discomfort.

The two most striking symptoms at this time were the following: While in the middle of a sentence the patient would suddenly stop, as if seized by a severe spasm of the pharynx. If this occurred in the middle of a word, the remainder of the word was prolonged into a harsh guttural sound. The patient choked, threw the head strongly backward, and pressed his hands upon the throat. This condition lasted some minutes, and usually ceased with the expectoration of a small quantity of white, frothy mucus. The patient at once became talkative, and insisted that he should be bled, in order to relieve the pressure about the throat. The pharyngeal spasms recurred at intervals of five to ten minutes, and were more frequent if the patient talked.

Although the patient was consuming with thirst, and was constantly asking for drink, it was impossible for him to swallow anything. He was able to take the glass in his hands and look at it; but on the attempt to bring it to his lips his head was at once turned away. If the effort was made to force him to drink, he was immediately seized with a violent spasm. The glass was then covered with cloth, so that the patient could not see the liquid; but the result was the same. The repulsion for solids was equally marked. The cutaneous sensibility was everywhere diminished. In administering a hypo-

dermic injection of morphia there was no manifestation of sensation on the part of the patient, least of all any sign of pain when the puncture was made.

There was no exaltation of the senses, and the patient had no hallucinations. He exhibited no tendency to violence, either toward himself or toward others. During the paroxysms, and in the agony of an attack of cramp, he cried out for relief, and called for poison ; but on the relaxation of the distress the longing to live returned. The skin was moist; temperature, 38.2° C. (100.7° F.); pulse, 116, soft and fluttering. There was manifest cardiac erethism. The tongue was moist ; there was no appearance of vesicles upon it. Bowels constipated, and there was no vomiting. Urine was passed naturally ; it was little colored, transparent, and contained neither albumen nor sugar. There was no sign of disturbance in relation to the genital apparatus.

During the night of April 10th to 11th the patient was very restless, obtaining absolutely no sleep, even by the aid of morphia and chloral. On the following morning he was a little more tranquil, but the sight of persons or things about him began to terrify him. He was still more talkative, pictured his sufferings in frightful colors, and demanded to be instantly cured. Were it not for the recurrent pharyngeal spasm, which preserved the same character and the same frequence, the appearance of the patient did not materially differ from that of a nervous person who is excited on account of some recent accident. The skin was still moist ; pulse, 120 ; temperature, 38.4° C. (101.1° F.). Urination was normal, and there were no signs referable to the genital organs.

At eleven o'clock the patient complained that he was left alone ; his agitation was more pronounced; his sufferings were more agonizing. At times he was suffocating from the severity of the pharyngeal spasm, sprang from the bed, and rushed to the window for air. The expression of the countenance was much changed. There was no tendency to become violent or to bite. On two occasions the patient begged his attendants to retire, as he felt that he was about to lose control of himself. The periods passed without any attempt on his part to bite, or to bring anything near the mouth or teeth. Respiration at this time was jerking and hurried.

The disposition of the patient was affectionate, and he constantly spoke of his family and friends.

The dysphagia was persistent and complete. The patient took the glass filled with water, and made repeated efforts to bring the liquid to his mouth by closing the eyes and turning the head, but was unable to approach the cup to the lips. The attempt was made to introduce liquids through a tube. As soon as a few drops had passed into the mouth, the whole was suddenly expelled by a spasm of suffocation of extreme violence. The thirst was most intense, and the patient frequently tried to take liquids by bringing a small amount in contact with the tongue, but he was unable to do so. The skin continued moist. No urine had been passed since early morning. Stool absent.

1.30 P.M.—The patient was visited for a few moments by his family, after which he was in a most excited condition. Hallucinations now appeared ; he thought that his father was by the bedside, and spoke to him. He appeared to be searching constantly for something, and looked anxiously in all directions. He thought that the solution of morphine was colored red. The special senses were in a state of exalted function, the patient was disturbed by the slightest sound, such as conversation in the adjoining rooms, even in whispers. He heard the voice of his father. He did not show agitation at the sight of bright objects, such as mirrors, watches, etc. He could still without difficulty place and retain his hands in a vessel filled with water, although all efforts to induce him to drink any liquid were fruitless. He could not swallow anything. He tried to take a part of an orange, but it was violently rejected.

The spasm and the salivation were increased. The patient was restless, uncovered himself, tried to sit upon the bed, etc. At times he was quiet for a few moments ; skin dry and burning ; pulse, 150.

Three o'clock.—Hallucinations of terror. The patient attempted to barricade the door of his room by means of the chairs. The spasm had become more violent, and he cried out in agony, and at times expectorated a moderate amount of viscid, frothy saliva. There was no tendency to bite. The intervals of quiet were shorter ; but at these times the entire body was relaxed. Temperature, 39.6° C. (103.3° F.) ; pupils punctiform.

The administration of chloral and injections of morphine now procured no relief ; but, on the contrary, furious delirium became rapidly more and more marked, so as to require the use of the camisole. The patient resisted the application of the camisole, saying that he had done nothing, and that the room might be locked, but that he would not submit to the jacket. With a great effort the camisole was applied, when he tore it in shreds, and seizing a slat from his bed, he crashed it through the window, and tried to escape. A stronger jacket was applied, and the patient was thus restrained.

Four o'clock.—The agitation was now terrific. The face had become cyanotic. The spasms were more violent, so that respiration was interrupted. The patient sweated profusely. Had passed no urine since morning. Pulse, bounding, 160. Rigidity of the neck and the limbs.

Five o'clock.—Collapse. Cessation of the cries, and cyanosis.

White, frothy saliva flowed from the mouth with each expiration. Respiration irregular. Pupils punctiform. Subjunctival ecchymosis. Corneal reflex almost absent.

Six o'clock.—Collapse more pronounced. Eyes largely opened ; pupils dilated ; corneal reflex absent ; corneæ dry. Profuse cold sweat. Respiration soft and still, but very irregular ; the contraction of the diaphragm was still marked, and caused the bed to shake at each inspiration. No alvine evacuation. Tympanites.

Seven o'clock.—Twenty-two respirations per minute ; irregular. Cyanosis more pronounced. White and abundant froth flowed over the face and neck. Pulse thready and tremulous, and could not be counted. Head, burning ; extremities, cold. Pupils very large. One hour later, dead.

Control Experiment.—Immediately after the autopsy (made fourteen hours after death), the pons, medulla, and cord were transmitted to M. Pasteur, with the history of the case. M. Roux made inoculations in rabbits, and the animals all died after an interval of fourteen days, with the typical symptoms of rabies, thus confirming the diagnosis.

It is important to distinguish rabies from other forms of tetanic diseases, or, in other words, from other forms of tetanus. The similarity between the rabic spasms and those due to other causes is so great that some authorities deny the existence of two diseases, and consider rabies to be one form of traumatic tetanus. Cases are recorded in which traumatic tetanus presented the specific symptoms of rabies, and were confounded with this disease. These doubtful cases are valuable as teaching that not all cases of this disease run an exactly similar course ; and that not all forms of the disorder are of service in explaining the pathology of the rabic process. The horror of liquids is not a common symptom of traumatic tetanus, nor is psychic disturbance a usual accompaniment of this form of tetanus.

The clinical history of rabies is often obscured or rendered difficult from the fact that the patient is inclined to deny the existence of a bite of inoculation, and the original wound is often completely healed at the time when the patient applies for treatment. Many cases of suspected rabies cannot be traced to the bite of an animal known to be diseased. Rabies is sometimes simulated by the symptoms of acute softening of the brain, or by those of acute meningitis ; but in these cases the most characteristic feature of rabies, the augmented irritability of the respiratory and of the reflex centres, either is not present at all, or is not a prominent symptom.

After death from rabies, the body is quickly distended by gas, which is formed in large quantities, and the post-mortem imbibition is usually strongly marked.

Clinical History.—The study of rabies must be considered to begin with the observation of the disease in the dog (rabies canina). There are two distinct varieties of the disease, the maniacal and the paralytic forms. The disease is marked by three stages: the prodromal, the irritative, and the paralytic. During the prodromal stage the animal is of variable temper, refuses his favorite food, passes quickly from excitement to depression and *vice versa*, swallows the most unusual substances, has generally a marked degree of sexual excitement, associated with a progressive, gradual weakening of the hinder extremities, trembling of the limbs, and a faltering gait.

The dog becomes unruly and obstinate, or sometimes timid and suspicious. There is often a marked secretion from the nasal passages, some embarrassment in swallowing, with a tendency toward vomiting. The original bite is generally quite sensitive at the time when the symptoms of the invasion of the disease begin to become evident. After a period varying from a few hours to three days, the symptoms belonging to the second stage are gradually developed and quickly become distinctly marked. The characteristic features of this stage consist in an evident tendency to roam, and to wander away from home. There is also at this time a marked disposition to bite, and there is an unmistakable change in the voice.

These symptoms are accompanied by undoubted indications of hallucinations of sight and hearing. The peculiarity of the voice consists in the prolongation of the initial bark into a protracted cry, the latter portion of which is raised in pitch to the octave, or nearly that, of the tone in which the cry commenced. The sound is more to be compared to a prolonged howl than to ordinary barking, but the intonation and pitch of the cry are unlike anything else in the way of canine sounds. There is usually at this time no hydrophobia in canine rabies. There is, indeed, marked inability to swallow either fluids or solids, the efforts to accomplish which often lead to vomiting. The loss of strength is therefore progressive and rapid. The mucous membrane of the mouth is often dry and fissured. Salivation is observed only in cases in which there is paralysis of the parts concerned in deglutition. The tongue, nose, and oftentimes the entire head are swollen, the conjunctivæ reddened, and there is usually photophobia. The respiration is generally hurried and difficult; there is frequently tenesmus, so that the passage of excrement is not only painful, but often impossible. The animal strains, and often the excreta are tinged with blood. The tenesmus is so frequently a symptom that some observers have considered that there is an intestinal lesion in the pathology of rabies.

A peculiar characteristic in the mad dog is the absence of the sense of pain—a red-hot poker will be grasped and held in the mouth. Dogs will bite themselves and still utter no cry. Periods of calm succeed these accessions of excitement, but during them the bite of the animal may still communicate the disease. Exhausted by the paroxysms, and the fighting and wandering, the dog will still continue on in its unsteady gait, with the tail between the legs, eyes wandering, the head rolling from side to side, and the mouth open with the tongue protruding.

Following the stage just described, and appearing as the intervals between the paroxysms of the disease become shorter, the paralytic stage supervenes. The hinder extremities become feeble, the voice hoarse, the respiration labored, and the heart's action accelerated. At times the convulsions appear early, and the animal generally expires after a longer or shorter period of coma, usually in from five to seven days from the onset of the disease.

Horses, cattle, and sheep, when affected by rabies, usually show no disposition to bite. Goats and swine are, as a rule, inclined to bite. Rabies is especially dangerous in cats and other carnivorous animals, on account of their greater ferocity. Domestic poultry is subject to rabies, and occasionally a tendency to bite is observed in these animals. True rabies is necessarily fatal in the present state of our scientific knowledge. Drugs and treatment of every kind, sort, and description, have been tried without avail (Mott).

Pathology.—Rabies is eminently an infectious disease, and is communicated from one animal organism to another by direct inoculation of the infective material. The pathology of rabies is not clear, and many observers have doubtless added to the existing confusion by recording the results of mistaken observations. The disease is eminently an acute and degenerative malady, and its special seat seems to be in the higher nervous structures. There can be no doubt that these delicate structures might suffer serious pathological changes, from the intensity of the disease, and undergo a more or less extensive process of acute softening, fatty degeneration, colloid degeneration, thrombosis, and other serious changes, from the presence of such an active febrile disturbance, with the added element of recurrent convulsions, even if rabies were not present. Many of the reported pathological appearances are unquestionably produced post mortem by the wounding of the softened and friable organs in making the autopsy. Benedikt, Hammond, Weler, and Putz have noticed changes of this character. In a case under the observation of the writer, in the Charité in Berlin, the autopsy was made by Professor Frerichs with his usual great care. The entire cerebro-spinal nervous system was examined, but no distinctive lesions were detected. When one considers the great delicacy of these organs, and the accidents to which they are exposed during the process of removal from the body, one can readily believe that many of the reported lesions, thought to be due to rabies, may have been mechanically produced at the autopsy. There is no disease in which the opportunities for mistaken pathological appearances are more abundant or more delusive than in rabies.

Rabies has practically been a disease of unknown character (pathologically) until within the latest years. The researches of the most celebrated observers have, however, led to the detection of an ever-increasing similarity between rabies and the class of diseases, also inoculable, which depend upon the presence of a definite organism in the body as the essential element of the disease.

The symptoms of rabies, in all cases, point to the infection of the system with the virus of the disease as the first source of the malady. The disease seems to depend upon the presence of a foreign element, partaking of the nature of the bacterial organism, or of a pathological ferment, which increases within the system and finally produces the explosion of the disease. From the nature of the phenomena it is evident that the seat of the active lesions is the nervous system, although all the tissues of the body are capable of communicating the disease.

The specific germ of rabies has not thus far been isolated, as have those of anthrax, tubercle, cholera, etc., nor have successful cultures of the infecting principle been as yet produced. The reported pathological appearances found in rabies are most various, and are often exaggerated by the results of accidental injury of the nervous structures from violence on the part of those making the autopsy. All observers, however, agree that there is evidence of molecular changes in the textures of the nervous tissues, chiefly of the nature of a granular degeneration of the nerve-elements, with the existence of granular deposits along the course of the smaller blood-vessels and lymph-channels. This material is so abundant as to occlude to a certain degree the calibre of the vascular channels, and to materially interfere with the nutrition of the nervous structures. The fact must not be forgotten that these changes, as well as many others, may, to a certain extent, be due to the great loss of liquids which the system has sustained; and it may also be in part accounted for by the violent convulsive movements which are so frequent and so distressing. The secretion of the saliva alone is sometimes enormous, and the other liquid secretions and excretions are also sometimes exaggerated during a part of the course of the disease, at the same time that the amount of fluid taken by the patient is greatly diminished. The nerves of the parts in which the original bite or inoculation occurred have been observed to present marked pathological ap-

pearances. The myeline is found in a diffluent condition, and in disconnected masses. The structure is softened, and the axis-cylinder is at times absent in many of the nerve-tubes. The same observation has been recorded in relation to the nerves arising from the medulla, the pneumogastric, the glosso-pharyngeal, and the hypoglossal; also the spinal accessory and the phrenic have been found to be the seat of ecchymosis and of localized apoplexies. Benedikt thinks the local lesions are sufficient to account for the clinical features of the disease. The digestive system is the seat of more or less pathological change, as might be expected, and there is often congestion of the liver and spleen.

PROGNOSIS.—The termination of rabies under any known form of treatment has been universally of a fatal character. Indeed, but few recognized diseases have so uniform and inevitable a tendency to a fatal issue, under all circumstances, as the dreaded malady of which we are now treating. Cases of the disease in which recovery has occurred are generally conceded to have been the subjects of mistaken diagnosis, or have been simply one of the simulating affections of which mention has already been made (Lyssa falsa seu nervosa).

Many methods of cure have been advanced in cases of rabies, and each recovery has been attributed to some new mode of treatment; but thus far no form of medication has proved to be of the slightest avail in the curative treatment of this dreadful malady. It would seem that any medical treatment should be directed to the reduction of the exalted susceptibility of the nervous system, and to the preservation of the strength of the patient. The administration of nervous sedatives or the employment of anæsthetics would seem to be indicated, together with most careful nursing, in the hope that the disease may run its course and at length subside.

Rabies simulates the class of self-limited diseases in many ways, both in its onset and in the character of its effects. As yet, however, there is no known method of prolonging the life of the patient in this disease. Professor Mott states that "true rabies is necessarily fatal in the present state of our scientific knowledge."

This seems the proper place to allude to the researches of M. Pasteur, of Paris, who for many years has labored in the department of experimental investigation in relation to infectious diseases, and has made many important discoveries in the domain of germ-pathology. He has succeeded in discovering the means of protective inoculation in several of the malignant diseases of plants as well as of animals. His researches on Anthrax, on the Phylloxera, on Rouget, etc., have been universally recognized.

The study of rabies by M. Pasteur has extended over a period of several years, and has been conducted with a degree of care and patience truly remarkable. He has found that the infective principle of rabies (which he calls a "virus," although the material of inoculation has not yet been discovered, either by culture or by any other method of procedure), when inoculated directly from the dog into animals of other species, is variously affected in the degree of its intensity, or, in other words, in its degree of virulency. Thus, when inoculated into the monkey, and propagated from one animal to another in a continuous series, the virus of canine rabies soon lost its virulent character and was no longer fatal to dogs on inoculation. If, however, the virus were propagated through a series of rabbits in the same manner, it was found that the virulency of the rabic poison was rapidly increased in intensity, so that the virus taken from a successive culture through a series of rabbits was found to kill dogs much more quickly than the original virus taken directly from rabic dogs (rage de la rue, Pasteur), in whom the poisonous principle seems to be possessed of a certain definite degree of virulency midway between that of the same poison when passed through the system of the monkey and that obtained when it is passed through rabbits (see "Comptes Rendus").

The specific element of rabies is not yet definitely determined, though Professor Pol, of Geneva, has announced that he has discovered a definite organism which can be isolated and propagated by successive cultures, and which possesses the property of inducing the rabic disease in dogs or other animals. This assertion is not yet verified by the confirmation of other observers, but there is reason to hope that the infective material may yet be isolated, and may be proved to belong to the same general class of organisms as that of anthrax, erysipelas, diphtheria, cholera, etc. Pasteur has determined that the seat of the rabic disease is the nervous system, especially the brain and spinal cord. By suspension of the brain or spinal cord in an elevated temperature, the virulence of the poison was found to be progressively diminished, so that by this means an attenuated or enfeebled virus may be obtained. The diminution of the rabic virulency was found to be regular and uniform in cords treated in this way, so that the degree of attenuation can be accurately estimated, and a virus of any desired degree of activity may thus be secured, from that possessing fatal power to one which provokes only a moderate amount of febrile or inflammatory reaction.

The next step was to test the value of protective inoculation by these attenuated forms of virus. This was first carried out on animals, and later, after numerous trials, upon the human subject (Joseph Meister). It was found that the animal system became easily tolerant of the rabic virus in a state of attenuation, and that more powerful forms of virus might then be inoculated without danger, until the original virus of the dog (rage de la rue), as taken directly from the rabid animal, might be injected directly into the tissues of the animal, on which the attenuations in increasing strength had been successfully employed, without producing the slightest symptoms of danger. Here, then, it was proved that the animals thus protected were no longer susceptible to the immediate effects of rabies, even when bitten by dogs which were unquestionably the subjects of this disease; at the same time that other unprotected animals, similarly bitten, invariably died of typical rabies.

There seems reason to believe that the inoculation with rabic virus, as thus practised, may protect the individual from the rabic disease, though the period of time through which the protection lasts is not determined; and it is yet too early in the history of this mode of prophylactic treatment to allow a settled opinion upon a point of such stupendous importance.

As far as a long series of experiments on animals can determine (see "Comptes Rendus"), the protection, for the time at least, seems to be all that can be desired. Rabid dogs have been made to bite a series of animals which had been protected by inoculation, and also a series of animals which were not so protected; the unprotected animals, without a solitary exception, died of rabies in all its terrible intensity, while not one of the protected animals was in the least affected.

The value of a complete "control" in experimental pathology, as a means of confirmation, cannot be more clearly demonstrated than in the present course of studies. In all the inoculations of the human subject there has been a control inoculation of a rabbit with the same material as was inoculated into the person.

The material used for inoculation is a portion of the spinal cord of a rabbit, which has been simply triturated with a small quantity of pure water or other bland and sterilized fluid, so as to reduce the substance of the cord to a more or less fluid condition. The matter for inoculation is not subjected to any further treatment, but the portion of water holding in suspension the bruised and finely divided substance of the cord is injected directly into the tissues of the patient. With each injection the tolerance of the system to the rabic virus is increased, and at each successive injection a cord may be used which is of a greater degree of virulency than those which have been previously employed, until, at the expiration of a certain number of days, the system of the inoculated individual is not susceptible to the poison of the most virulent form of rabies in the dog or in the rabbit.*

* During December, 1885, several children were bitten by the same supposed rabid dog, in the streets of Newark, N. J., United States. The actual condition of the suspected dog was not satisfactorily ascertained,

PROPHYLAXIS.—This may be divided into two sections —*general* and *protective* prophylaxis.

I. *General Prophylaxis.*—Among the most important elements of purely prophylactic treatment of rabies must be classed that which pertains to the management of dogs in large towns, which are not the subjects of rabic disease. There is probably no measure of public hygiene which is followed by more certain and positive results than those which have been attained by the compulsory muzzling of all dogs which are allowed to be at large, and the prompt destruction of all dogs found in the streets without a muzzle. In the city of Berlin, where this ordinance has been in force for some years, there has not been a case of rabies for many years.

There can be no doubt that this mode of treatment of metropolitan dogs would be the most practical, and at the same time the least objectionable method of securing the public against the ravages of the rabic disease, so far, at least, as city dogs are concerned. It would not, perhaps, affect dogs in rural neighborhoods, nor would it materially diminish the dangers from rabies derived from other animals, such as wolves, foxes, skunks, etc., as the rabic disease is rarely communicated to them from dogs, but more frequently they are the source of infection of dogs or other domestic animals, and at the same time they are the cause of the disease in not a few instances in the human subject.

The wearing of a muzzle is not a hardship for the dog, as it can be made of metal, and may be so constructed as to be at the same time both light and strong, and in no material way diminish the comfort or impede the movements of the animal, except in the one feature of restraining him in any attempt to bite either men or other animals. The muzzle might be easily removed, and during all that portion of the day in which the dog is kept on the premises of the owner, he might go about without being muzzled ; but when at large the muzzle could be easily slipped over the animal's head, and thus the danger of his biting anybody be removed.

Dogs do not, as a rule, find the muzzle any inconvenience, and appear quite as cheerful when muzzled as when unmuzzled. Respiration is not impeded, nor are the motions of the dog in any way interfered with. The only effect of a proper muzzle is to prevent the dog from seizing any article, or taking a grip in any effective way with the teeth.

Another element of prophylactic treatment is the important one of the impounding of all suspected dogs, and their retention in some secure place, where careful observations may be made and their condition be satisfactorily ascertained. If rabies be present in a suspected dog, the disease will surely manifest itself in a few hours or days, and all doubts in relation to the existence of the disease will be dispelled. No suspected dog should be killed until such observations have been made, unless experimental inoculations are carried out by means of the injection of portions of the nervous system, as a control of his condition. The foolish idea that immediate destruction of the suspected dog is a source of protection to any person who may have been bitten by him is still extant, and often prevents investigation of the actual condition of the dog, by which, in most cases, all fears from the bite might be effectually laid at rest.

II. *Protective Prophylaxis.*—The extensive researches of M. Pasteur into the pathology of rabies have developed the important theory, which has now become an established belief, that the inoculation of the system with the virus of this disease is the means of securing immunity from the attack of this most frightful malady, after the introduction of the infective material into the body from the bite of a rabid animal.

The present state of this most important question is well set forth in an article contained in the *Annales d'Hygiène Publique*, December, 1886, which is here reproduced almost *in toto:* "It is now one year (October 26, 1886) since Pasteur made the announcement of the prophylaxis against rabies after a bite from a rabid animal. A large number of experiments upon dogs warranted that the attempt at protection be extended to the human subject. This was at length done, and up to March 1st 350 persons, who had been bitten by dogs known to be the victims of rabies, had been treated by Dr. Grancher in the laboratories of Pasteur.

"At this date, October 31, 1886, the number of persons who have submitted to the protective inoculations in Paris is 2,490. The treatment has been absolutely uniform for the great majority of those bitten, notwithstanding the diversity of age, sex, the number of wounds, the seat of the lacerations, their depth in the tissues, or the length of time which has elapsed since the reception of the injuries until protective treatment was instituted. The period of treatment extended over ten days. Each day the person treated received one injection of the spinal cord of a rabbit, commencing with a cord which had been dessicated for fourteen days, and finishing with one of five days.

"The entire number of French patients, being those dwelling in France, or French persons coming from Algeria, who have been inoculated during the last year is 1,700, and we can properly limit our observation to the description of the treatment of this quite considerable number of French-speaking people, and may form an opinion of the effect of the inoculation by a study of these cases.

"Among these 1,700 patients there were ten in whom the effects of the inoculations were not productive of immunity from the occurrence of rabies. These were the following cases: Those of the children Lagut, Peytel, Clédière, Moulis, Astier, Videau ; the women Leduc (seventy years of age), Marius, Bouvier (thirty years of age), Magneron (eighteen years of age). Two cases, those of Louise Pelletier and Moermann, are not included in this category, on account of their very late arrival at the laboratory, by reason of which the efficiency of the protective inoculations may have been modified, or the disease may have been already developed before their appearance in Paris. One case of death in each 170 persons bitten is, then, the result of this method, for France and Algeria, during the first year of its application as a protective against rabies. Taken as a whole these figures demonstrate the efficacy of this method, which is equally proved by the relatively large number of deaths among those bitten but who were not vaccinated. One may feel certain that during the year 1885-86, there were comparatively few persons bitten by mad dogs in France who did not apply for protection at the laboratory of l'École Normale. Even in this small minority there were, to my personal knowledge, 17 cases of death from rabies." (In a note, M. Pasteur gives exact reference to each of these cases, none of whom was inoculated for protection.)

"During the last five years sixty persons have died from rabies in the hospitals of Paris. That is an average of twelve per year. No year of the series was exempt from a certain number of deaths. During the last year of the series, the number of deaths was twenty-one. Now, since November 1, 1885, which was the date of the introduction of protective inoculation for the human subject into practice, in my laboratory, there have been in all the hospitals in Paris but two cases of death from rabies, neither of whom had received protective inoculation

as the animal was immediately killed. The children were sent at once to Paris by public subscription, and there, immediately upon their arrival, received the protective inoculations at the laboratory of M. Pasteur. The virus was prepared from the spinal cords of rabid animals in the manner above described. The first inoculations were with virus which had been much attenuated. With each succeeding inoculation the virulent quality of the inoculation was increased, until the material used was the virus taken from an animal newly dead from rabies. As soon as this limit was reached the children returned to the United States, where they have since that time been under careful observation by competent medical men, and up to the time of the present writing (twelve months) they seem to be free from any tendency to the disease.

The above reported cases are the first instances in which the protective vaccination has thus far been the subject of observation in the United States, and are of great interest on that account, though there is some uncertainty as to their absolute value, owing to the absence of positive knowledge as to the condition of the dog by which these children were bitten. Nine other dogs were said to have been bitten by this dog on the same day that the children were bitten. These nine dogs were all secured and impounded, where they were kept under observation during the period of three months. At the end of this time none of these dogs had showed symptoms of rabies, and they were all set at liberty.

(Raffin, at Hôtel-Dieu, and Riffandi, at Hospice Beaujon), and a third who had been inoculated, but not by the repeated intensive method, of which I will speak later (Clerjot, at Hôpital Tenon).

"It will be observed that the larger number of those who have succumbed to the disease, in spite of the treatment, are children, and that they were bitten in or about the face. These children received only the first simple form of treatment. I have since become convinced that this form of treatment, particularly in cases in which the wounds were of this character, runs the risk of being insufficient. Unfortunately, this conviction was reached only gradually, and after long study, which was necessary to establish the fact of an exceptional duration of the period of incubation in certain cases of rabies. The history of the disease among the Russian patients from Smolensk was the first proof of this fact which had come to our notice. From these cases we learned that there is a vast difference in the results of infection with the rabic virus, whether the source of infection be a mad dog or a mad wolf.

"From reliable sources the following statistics have been collected in relation to the bite of rabid wolves. These are published for the first time.

"1. On February 27, 1796, eight residents of Saint-Jullien de Civry, in Bourgogne, were bitten by a mad wolf. One died on the same day from the severity of his wounds. The other seven died after a period of incubation extending from seventeen to sixty-eight days.

"2. December 26, 1806, nine persons were bitten by a mad wolf in the vicinity of Bourg. Of these eight died of rabies.

"3. On October 16, 1812, nineteen persons were bitten by a mad wolf in the town of Bar-sur-Ornain. All of these patients were at once treated by Drs. Champion and Moreau, who washed the wounds and cauterized them by means of nitrate of antimony. Eleven of those bitten died of rabies after a period of incubation of seven to seventy days.

"4. On February 23, 1849, a shepherd in Darbois, named Dumont, sixty-four years of age, was bitten by a mad wolf. He died, after a period of incubation of thirty-two days, of typical rabies.

"5. On January 7, 1866, three inhabitants of the three neighboring hamlets of Nant, Alques, and Saint-Jean du Bruel were bitten by a mad wolf. All three died of rabies on the twenty-second, twenty-third, and thirty-eighth days.

"6. On October 5, 1874, two men were bitten in the village of Rochette by a mad wolf, who had just seized a little girl and had torn her in pieces. After twenty-five and thirty days, respectively, the two men were seized with the disease, and died of rabies. The child died on the day of the attack, from her injuries.

"7. In a letter of March 26th, Dr. Nipce, of Eaux de Allevard, communicated to Professor Vulpian four cases of bites from a mad wolf, occurring in the year 1822. The four persons died of rabies, after a period of incubation of from nine to nineteen days.

"8. On May 11 and 12, 1811, a mad wolf, in the vicinity of Avallon, bit several persons and many animals. All the persons bitten died of rabies. The dates of death in the different cases, as taken from the records of the hospital, vary from the twenty-fourth to the thirty-first day after inoculation.

"From a comparison of these reports we arrive at the ratio of 82 deaths in 100 cases of inoculation from rabid wolves. In six of these eight reports there were as many deaths as there were persons bitten, hence the ratio would be in these cases one hundred per cent. of fatal cases.

"The above reports prove that, first, the incubation of human rabies after the bite of a rabid wolf, is often very short, much shorter than is the case after rabies from the bite of a mad dog.

"Second, that the mortality in consequence of the bite of a mad wolf is much greater in comparison than is the case after the bite of a mad dog. If we apply these facts to the cases of the nineteen Russians from Smolensk, whose treatment is finished, and of whom sixteen have returned to Russia, we could have reckoned not upon three deaths from rabies, but upon fifteen out of sixteen! In Russia it is universally believed that no one who has been bitten by a mad wolf can escape death from rabies.

"When we saw three of those nineteen patients from Smolensk die from rabies while under our observation—the first being in the course of the former simple treatment, and the two others having already finished their treatment some days before—we were much troubled. Would the sixteen others also become victims of rabies? Was the method unavailing against rabies derived from the wolf? We then recalled the fact that all the dogs which had been vaccinated with success had received, as the last preservative inoculation, a preparation from a virulent cord removed the same day, and that the first person to undergo vaccination, Joseph Meister, had finished the treatment by a cord which was removed the evening previous to being used. We then at once made a second and a third course of inoculations upon the sixteen Russians who still remained alive, increasing the intensity of the inoculations until the cords of the fourth, third, and second day were reached. It is very probable that to these repeated inoculations is to be attributed the cure of these sixteen Russians. A despatch received on the day of this report from the Mayor of Beloi, announces that these patients are all in the best of health.

"Encouraged by these results, and by the new facts obtained thereby, a new method of treatment has been adopted, by making the inoculations more rapidly, and of more active quality, in all cases of wounds of the face, or in cases of deep wounds and multiple lacerations upon other uncovered parts. Three complete treatments are therefore made in the space of ten days, and in each treatment the last cord used is one of most virulent intensity."

The opinion of the profession upon the discoveries of Pasteur is very clearly set forth in an address by Dr. T. W. Hime, in the London *Lancet*, December 11, 1886.

Dr. Hime says: "The success of Pasteur's treatment has been brilliantly demonstrated by statistics as well as by experiments. That the disease in the rabbit from which Pasteur obtained his material for human inoculation was true rabies is indubitable. Nerve-matter taken from such a rabbit and inoculated in a dog intracranially, the only certain method, invariably produces true rabies. If nerve-matter be taken from a human being dead from an attack of canine rabies, and be inoculated in a rabbit, a guinea-pig, a dog, all three will take rabies and die. The dog will have rabies according to his kind, with symptoms either of the dumb or of the furious kind. The guinea-pig will exhibit very characteristic symptoms, and the rabbit will develop symptoms peculiar to his kind, such as for convenience may be called the 'Pasteuran disease,' but an interesting and important fact may be borne in mind. The virus used for the experiment, being canine virus, which has passed once through the human subject, will retain certain canine peculiarities as to period of incubation, date of death, etc. If, instead of human nerve-tissues from persons who have died from canine rabies, we employ nerve-matter direct from a dog which has died from rabies, for inoculation, the animal will be similarly affected, and the disease produced in the rabbit cannot be distinguished from that caused by inoculation with nerve-matter taken from a human being who has died from rabies after inoculation with canine rabies.

"If, again, nerve-matter be used taken from one of the rabbits employed by Pasteur for protective inoculation, the same result will be obtained, with this difference—the course of the disease in the various animals will be shortened. Pasteur uses for his protective inoculations virus which, originating in ordinary canine rabies, has been passed directly from rabbit to rabbit some hundreds of series. The result is that the virus has become intensified, and kills more rapidly than the original canine virus. It was actually alleged at one time that the deaths following Pasteur's inoculations were due to them. This was triumphantly disproved by the experimental demon-

stration that the virus in the disease was canine virus (and was due to the original bite), and not rabbit virus inoculated by Pasteur for protection. The opposite result is obtained if the virus be passed from monkey to monkey through a long series; the virus becomes weaker and weaker. But no doubt, just as the virus of anthrax, or fowl cholera, which has been modified by cultivation, could be brought back to its primitive virulence, so the weakened rabic virus of the ape and the intensified rabic virus of the rabbit could be brought back to the original degree of virulence. If Pasteuran virus be passed through the dog once, and then be inoculated on a rabbit, it will be found not to have resumed canine characteristics by passing once through the dog. But more frequent passages through the dog will probably restore its primitive characteristics. The symptoms are very special in the rabbit inoculated with Pasteuran virus; the length of the incubative period (five to six days), and the date of death (nine to ten days), are more invariable than in any other known disease of man or animals. Further, the symptoms are very characteristic and invariable, notably the slightness of the general symptoms, even after paralysis has become marked. The temperature is also very interesting, and markedly different from that found after intracranial injection with other materials than the Pasteuran virus or rabic virus from some other source. The following is a characteristic chart of the temperature of a rabbit which died of Pasteuran rabies: First day, 102.6°; second day, 103.0°; third day, 102.8°; fourth day, 103.0°; fifth day, 104.2°; sixth day, 105.6°; seventh day, 105.8°; eighth day, 106.4°; ninth day, 104.1°; tenth day, 97.0°; eleventh day, 86.0°.

"The febrile stage may be shorter, and the fall more gradual, but the latter is always great. The elevation is not always so great as in this example, but the rhythm is characteristic, and the temperature usually gives indication before the actual symptoms appear. The course of the temperature in the rabid dog is similar. At first there is no change; then the temperature rises gradually and may reach 105.0° or 106.0°. The period of acme lasts one or two days, and is succeeded by a rapid fall to about 84.0°, when death ensues. The fact that the disease is always and invariably transmissible by inoculation is of great importance as regards its pathology, and as distinguishing it from other diseases. With regard to post-mortem appearances, there is nothing pathognomonic in the Pasteuran rabbit, any more than in the dog, or in the human subject dead from rabies. All the organs appear free from disease; some more or less hyperæmic; and sometimes hæmorrhages are found; the brain is slightly hyperæmic as a rule, the heart contracted, and the bladder generally full. The stomach almost invariably contains food; the cæcum is commonly full; the remainder of the intestine generally contains but little; the small intestine nothing. This absence of morbid conditions is remarkable, and is certainly not found after death from injury to the brain after operation, nor after death from intracranial injection of other materials—putrid material, etc. In this case, pus would be found within the cranium, and other evidence of purulent absorption would be detected.

"Intracranial injection of sterilized bouillon will not produce the symptoms of Pasteuran disease, nor any other morbid symptoms, and rabbits so injected will not die if skilfully operated upon. Rabbits inoculated according to Pasteur's methods, with sterilized bouillon rubbed up with putrid meat, will die, but with symptoms entirely different from those of Pasteuran disease, and without the characteristic paralysis. But still more noteworthy is the fact that the disease produced by injections of putrid material is not transmissible. If fresh nerve-matter be taken from a rabbit which has died in consequence of disease produced by intracranial injection of putrid matter, and be injected intracranially, according to Pasteur's method, on another rabbit, the latter will not die, and will have no specific disease whatever, nor marked symptoms of any kind if skilfully operated upon. But the Pasteuran disease is always transmissible by intracranial injection. Nerve-matter from dogs which have been suspected of rabies, and have died or been killed in consequence, has been frequently injected intracranially on rabbits as a diagnostic measure; if the dogs were rabid the Pasteuran disease will be developed in the rabbits. If not, the rabbits will survive, without showing any symptoms of this disease or any other disease. That this crucial method of diagnosis exists is due to Pasteur. In fine, the following results are established: the virus used by Pasteur for protective inoculation originated in the rabid dog, and is the virus of rabies. Pasteur has published results showing that the material used for his latest protective inoculations on man, caused rabies in animals which were unprotected. If virus be taken from a rabid dog, and be passed through a series of rabbits, it will produce the same disease as is developed in the rabbits from which Pasteur takes his matter for protective inoculations. If the virus of such inoculations be inoculated back into the dog or other susceptible animal, it will produce true rabies in them, and if then passed back to the rabbit it will produce the same symptoms *ad infinitum*.

"Human rabies, if inoculated on the rabbit, will produce the same symptoms, with such variations as are due to its origin in the dog, cat, etc. These variations are exhibited chiefly in the period of incubation, and the period elapsing before death, the disease invariably terminating fatally. No other known disease produces the same results, nor can the symptoms be caused either by surgical brain-lesion or the intracranial injection of inert material, such as sterilized bouillon, or with putrid material. The Pasteuran disease is specific, and very distinctly characterized by its course and symptoms, which are different from those of any other disease; it invariably ends fatally, and is indefinitely transmissible by inoculation from animal to animal. The protection afforded to dogs by Pasteur is proved beyond doubt or question, and analogy suggests that the same method is applicable to man. Dogs can be protected either by inoculation before infection, or after this has occurred. Further, they have been protected against the action of the rabbit virus, which is much more active than ordinary canine virus. The reality of this protection establishes the truth of Pasteur's principle. His practice may be capable of improvement; but he has already effected a great deal in a short time. It has been objected that the inoculated prophylactic virus is inert, because the patient shows no specific reaction. It is almost always the case that there is a slight though decided reaction. Pasteur has established a prophylactic treatment against rabies, one of the most formidable, and hitherto intractable, diseases. He has thus crowned a glorious career of research directed to the benefit of man by a most notable discovery, primarily salutary to man himself."

The statements of Dr. Hime are corroborated by the report of Dr. Grancher upon the cases treated by Pasteur's method in the laboratories of the institute, which is as follows (up to April 22, 1886):

"The cases were divided into three classes. The first class included those bitten by dogs proved to be mad by the inoculation of rabies, or subsequent development of rabies in animals bitten by them. These amounted to 96 cases, and contained one death. The second class comprised patients bitten by dogs certified to be rabid by the veterinary practitioners of the locality, and numbered 644 cases, and two deaths. The third class contained those bitten by dogs who had run off and had not been seen again, 232 cases, with no deaths.

"In the first two classes, 740 cases, with three deaths, not quite one-half of one per cent. of those bitten; while the ordinary statistics of light cases given by M. DeBlanc, Veterinary Surgeon of the city of Paris, gives sixteen per cent. as the number of deaths. Dr. Brouardel has calculated that no less than eighty per cent. of those bitten by rabid dogs on exposed parts of the body die. In the 84 cases of wolf-bite, not included in the above, 7 died; ordinarily sixty-six per cent. of those bitten by rabid wolves die, and here the percentage is fourteen."

Dr. H. C. Ernst, in a recent paper (*American Journal of the Medical Sciences*, April, 1887), describes a series of

experiments performed in the Bacterial Laboratory of Harvard University, from which he deduces the following propositions:

First, is there a specific virus in the brains and cords of rabbits inoculated with Pasteur's materials, and after his methods?

Second, does the treatment by drying, proposed by him, modify the strength of this virus? and

Third, does injection with such "modified virus" produce immunity against inoculation (or bite) with virus of full strength?

The essay closes with the following:—The conclusions which may be drawn from the work here recorded seem to be as follows:

1. There exists in the cords and brains of animals inoculated in Pasteur's laboratory a specific virus, capable of the production of similar symptoms through a long series of animals.

2. These symptoms are produced with absolute certainty when the method of inoculation is by trephining the skull, and in injection under the dura mater; with less certainty when the inoculation is by subcutaneous injection.

3. The strength of this virus is lessened when the cords containing it are removed from the animals and placed in a dry atmosphere, at an even temperature.

4. The symptoms produced by the inoculation of this virus appear only after a certain period of incubation, distinctly shorter when the inoculation has been done by trephining than when done by subcutaneous injection.

5. The injection of the virus, modified in strength by drying, and in the manner prescribed by Pasteur, exerts a very marked protective influence against an inoculation with virus of full strength.

6. A very moderate degree of heat destroys the power of the virus entirely, while prolonged freezing does not injure it.

TREATMENT.—In the actual care of cases of rabies, in any form, the treatment is essentially divided into two distinct forms: the prophylactic and the clinical.

The first consists in the destruction or the confinement of all suspected animals, and the isolation and careful and lengthened observation of all animals which have shown indications of rabies, and which have bitten other animals or have attacked men. The disease is usually developed in the dog within a certain tolerably definite period, and if the imprisoned animal demonstrates no indications of the disease within these limits, it is fair to assume that rabies was not communicated by the same dog in biting other animals or men.

The second part of the prophylactic treatment of this disease consists in the early and proper care of the wounds caused by the bite of animals thought to be rabid. All such wounds should be promptly cauterized by means of the ferrum candens, nitrate of silver, caustic potash, or by some other efficient means.

After cauterization the wound may be completely excised.

It is considered a wise procedure to maintain suppuration in the wound for a long time. The safety of the patient is increased in proportion to the earliness of the treatment of the wound. Sucking of the wound is a usual procedure, but it may be a dangerous measure on account of unnoticed injuries of the mucous membrane of the lips or mouth, by which fatal infection of the system might occur. This mode of treatment requires an unusual amount of courage and self-sacrifice.

The therapeutical measures in this disorder relate to the treatment of the disease after it is actually and unmistakably developed. In view of the fact that cases of this disease are uniformly and inevitably fatal, and that no known method of treatment is able to prevent the lethal result, there is little to be hoped from any mode of procedure.*

It is important that the care of patients with rabies should be entrusted to responsible and skilful nurses, in order to avoid the employment of force in restraint, by which the patients might be injured, or which might unnecessarily increase the excitement and anxiety of the patients. The subject with rabies (human) is not dangerous to those about him, nor is he inclined to injure himself.*

All appearance of forcible restraint or of fear should be removed, and the patient should be comforted as much as possible.

The terrors of this fearful malady are greatly intensified by the unnecessary fear, and often by the cruelty, of those about the patient.

We know of no method of favorably affecting rabies in the way of treatment when the disease has once appeared. We do not even know how to ameliorate the agonies of the severer symptoms.†

Among the measures which may be adopted are certain influences addressed to the mental and moral condition of the patient, by which some degree of relief may often be secured. Thus drinks may be taken through an opaque tube, or from a dark-colored vessel, so that the fluid may not be seen by the patient.‡

Much relief may be secured in some cases from the subcutaneous employment of morphine; the application of electricity has also at times seemed to be of service.

The great question, whether there is any other method of treatment of rabies than that of protective inoculation by means of the attenuated virus, by which the disease may be controlled when infection has occurred from the bite of a rabid animal, is one of the undecided problems of our science. From the stupendous strides which have been made in the advancement of therapeutical knowledge, particularly in relation to the products and effects of the large class of synthetic compounds, there is reason to hope that we may at length acquire the means of restraining infectious diseases, due to the invasion of the system by pathogenic bacterial forms, or to other infective agencies, if such other agents of infection exist. With the attainment of this increased ability to combat the development of the specific germs, we shall possess the means of limiting and controlling the ravages of epidemic diseases. The scope and importance of such a tremendous addition to our therapeutical resources is

* In connection with the above statement should be considered the lengthy description, on a previous page, in relation to the treatment of rabies by protective inoculation or vaccination, as devised and practically carried out, in relation both to the lower animals and to man himself, by M. Pasteur, of Paris. The value of this new method of treatment is not yet fully and satisfactorily demonstrated in relation to the human subject, and therefore it cannot be said to have yet actually taken the position claimed for it as a therapeutical and prophylactic measure, though there are strong reasons for the hope that it may prove to be a safe and sure preventive of the rabic disease.

* Benedikt mentions a case in which a dog-fancier was attacked, after many years, by rabies, following a new and recent bite by a dog, and on experiencing the first symptoms of the disease he hanged himself; but the tendency to self-injury is small in this disease.

† Kostyleff reports a case of rabies treated by inhalations of oxygen. The patient was a railway guard, sixty-three years of age, and intemperate, who had been bitten by a suspicious dog about four months before his admission. The symptoms of rabies consisted of an extraordinary sexual excitement, malaise, loss of appetite, and thirst. Three days later he was brought to the hospital. There was then hydrophobia and pain in the throat. Respiratory and pharyngeal spasm was frequent, and there was frothy expectoration mixed with blood. The patient was in a state of intense general excitement, with delirium of persecution. The effect of the inhalations of oxygen was most pleasing. After the first few inhalations the spasm entirely ceased, the expectoration was diminished, the cyanotic lips became rosy, the patient passed into a calmer condition, and could eat, drink, and smoke. After one and a half hour's sleep at night there was a return of the spasm with dyspnœa, which was again cut short by the oxygen. After an enema of chloral he again slept several hours, and then he was able to take two or three glasses of milk. On the following day he was able to drink, but soon after this time the delirium returned and he became gradually exhausted, and died on the fourth day. Kostyleff therefore thinks oxygen to be markedly palliative, but not curative.

‡ A man was admitted into the Massachusetts General Hospital in September, 1878, who had been bitten, as he claimed, by a rabbit, and had developed symptoms of rabies. The patient had no suspicion of the nature of his disease, and was not informed of the character of the malady while in the hospital, and died without knowing that he was affected with rabies. The attempt was made in this case to introduce fluids by means of opaque tubes, and by using darkened vessels, but without avail. The patient would at once experience the most frightful convulsions if his fingers were dipped into any fluid, even if he could neither see nor hear the liquid. The patient's condition gradually became more and more excitable, and he passed into a state of frenzy, in which he made his escape from the hospital, and was with difficulty retaken. He was brought again to bed, and died a short time afterward from exhaustion.

too vast and far-reaching for our present conception. The attainment of the result thus hinted at is no chimera, but is a warrantable expectation.

As a contribution to the possible therapeutics of rabies may be mentioned a case occurring in the practice of Dr. De Capua, of Naples, in which a patient, suffering from undoubted rabic symptoms following the bite of a mad dog, was treated by subcutaneous injection of mercuric bichloride, together with atropine. The case is reported in brief in the London *Lancet*, September 18, 1886. The rabic symptoms amended slowly, and the mental phenomena at the same time subsided in a gradual manner. The delirium assumed three distinct forms, and ended with a form of mental disturbance related to the occupation of the patient as a farmer; this soon abated, when complete physical and mental recovery took place.

Jagell, *Revue Scientifique*, August 21, 1886, quoted in *Medical Record*, January 1, 1887, treated eighty-eight cases resulting from the bites of rabic wolves and dogs, and all were cured by infusion of spiræa filipendula; twenty-six of these cases having been found already in the first stage of hydrophobia when treatment was commenced.

NOTE.—Since the above article was written, the protective inoculation, in cases of threatened rabies from the bite of a rabid animal, has been made the subject of unceasing study and experimental research by able men in every country. The general opinion has been that inoculation in the way advocated by Pasteur is not only an absolute protection to the patient against the outbreak of the rabic disease, but that it is itself entirely free from serious effects upon the inoculated person. For an interesting account of Pasteur's method and its results, as seen by Dr. Ullmann, of Vienna, see *Wiener Allg. Med. Zeitung*, 1886, No. 21. Dr. Ullmann allowed himself, as did also four other physicians, to be inoculated with the rabic virus. All remained well, and with the exception of moderate constitutional disturbance, experienced no deleterious effects from this courageous experiment.

For an exhaustive treatise upon this subject, with numerous references, see article on "Hydrophobia," by Bollinger, in "Ziemssen's Cyclopædia of the Practice of Medicine," American translation, vol. iii., p. 432 *et seq.*; also Pepper's "System of Medicine," vol. i., p. 886.

Albert N. Blodgett.

RAGAZ-PFÄFERS, called also Pfäfers-Ragaz, is a spa in Canton St. Gallen, Switzerland. There are really two establishments, but both receive their water from the same spring. Pfäfers is the higher (2,200 feet above sea-level) and Ragaz lies below, at an elevation of 1,700 feet. The climate is less raw and changeable in Ragaz, though in neither place is it very warm; by reason of their situation in the valley these stations enjoy the direct sunlight for only about six hours out of the twenty-four. The following is the composition of the water, according to the analysis of Planta.

One litre contains:

	Grammes.
Lithium chloride	0.002
Sodium chloride	0.493
Sodium sulphate	0.329
Calcium sulphate	0.075
Sodium borate	0.004
Sodium carbonate	0.061
Magnesium carbonate	0.531
Calcium carbonate	1.306
Strontium carbonate	0.015
Barytum carbonate	0.006
Ferrous carbonate	0.017
Aluminium phosphate	0.009
Silicic acid	0.141
Total	2.989

There are also traces of iodine, bromine, rubidium, cæsium, and thallium. The temperature of the water at Pfäfers is 99.5° F., but by the time it has reached Ragaz in the pipe-line conduit, it has been cooled to about 95.5° F. The waters are taken internally and in the form of baths, douches, etc. They are recommended chiefly in the treatment of excited nervous conditions, and of chronic rheumatism and gout. The season in Ragaz extends from the beginning of May to the end of October; in Pfäfers it is about two months shorter. In addition to the use of the thermal waters, there are facilities for the "whey" and "grape" cures. *T. L. S.*

RAILWAY MEDICAL SERVICE. In the infancy of American railroads, while they were few, short, and nowhere distant from centres of population, it could not have been supposed that the companies would derive any advantage from an organized medical department; nor is it likely that such a want was then anticipated, any more than an occasion for undertaking the business of mining, manufacturing, or the extensive planting of forest trees. But, as lines lengthened and business increased, occasions for surgical relief to passengers and employés multiplied, and the advantage of definite and permanent engagements with medical men became apparent.

It is evident that a strong corporation, well organized for a particular purpose, has facilities for undertaking new functions; and medical relief to employés, when they became numerous, would seem as natural a want as in a military establishment. But the actual outgrowth of railway medical service in Great Britain and the United States has been governed by the apparent necessities of companies, to obviate the greater expense of employing medical men only when their services were indispensable, and at their own prices. In France and other countries of continental Europe, where railroads have always been more or less under direct governmental control, and where a paternal government assumes complete supervision of the conduct of its subjects, a well-organized medical department has long existed on the more important roads.

The first, and for some time the only, occasions for the employment of medical men by railway companies were in a surgical capacity, for the relief of those injured in accidents, when it might be presumed that the companies would be held legally responsible for consequences. A service once organized for this purpose could be made available, without much additional expense, for the relief of employés, and even of their families, in ordinary sickness. The physical examination of employés followed later, and, last of all, hygienic measures for the prevention of disease. These come latest, not because of inferior importance, but because they are the highest development in the gradual evolution of medical science.

The medical service of some of the principal railways of France and Italy is the most elaborate in the world, and will properly serve as a model for general imitation, as it has already on the continent of Europe, and to some extent in British India, in Australia, and by a few companies in the United States. The medical department of the Paris, Lyons & Mediterranean Railroad has its headquarters at Paris, and is administered by a physician-in-chief and a number of district physicians, who are practitioners residing at convenient distances along the lines. All receive fixed salaries, and their duties are defined as follows:

The district physicians are required:

1. To attend gratuitously upon sick and injured employés, and all other persons accidentally injured upon the lines or in the premises of the company.

2. To ascertain and certify the general health and degree of corporeal fitness of applicants for the various branches of service, after careful physical examination.

3. To answer all calls for attendance in case of accidents upon the lines and in the establishments of the company.

4. To advise the directory in questions of hygiene and in the settlement of damages for personal injuries.

5. To inspect monthly, as far as possible, all establishments whose *personnel* is entrusted to their care, in order to certify their sanitary condition, and to inspect the relief-chests, medical stores, and apparatus of the medical service.

6. To report monthly to the physician-in-chief the condition of the sick and wounded, and the results of the inspections, adding thereto any necessary observations and requisitions.

7. To certify and countersign bills of hospitals, apothecaries, and other purveyors, and those of private physicians, previous to forwarding the same to the physician-in-chief.

The duties of the physician-in-chief are:

1. To supervise the medical service of all the company's lines, and inspect the same as often as he deems proper.

2. To examine and countersign all bills for ordinary expenditures (those of hospitals, apothecaries, and other purveyors), and to advise superintendents of the operating and construction departments concerning extraordinary expenditures of the medical service (bills of private physicians, thermal-water establishments, indemnity for personal injuries, etc.), before transmitting them to the central bureau of accounts in the department of operation.

3. To consider all matters which are to be submitted to the superintendents of operation and construction, such as applications for extension of medical relief, for sending to mineral springs, and for indemnity on account of injuries; investigations and reports upon grave accidents; applications for positions in the medical corps.

4. He also receives the monthly reports of his subordinates, and consolidates their statements concerning the general health of the *personnel* and sanitary condition of the company's property into a general report, which he makes annually to the general manager, and in which he includes his own observations upon prevailing diseases and upon the medical service in general.

5. The physician-in-chief is, besides, charged with the general superintendence of the medical service; with receiving petitions or claims addressed to him by physicians, superintendents, or sick persons, in matters which concern the medical service; with the collection of documents which may contribute to improving the health of employés and the sanitary condition of the company's establishments; with assisting personally, in case of grave accidents, in the organization of relief, and with aiding by counsel and influence, in concert with the legal service, the adjustment of indemnities for personal injury; with making several times a year an inspection of the medical service and of the company's establishments; with suggesting any hygienic or medical measures which he may deem expedient to the company.

6. All petitions, documents, letters, etc., relative to the medical service, are sent to him through the administrative channel.

MEDICAL EXAMINATION.—No individual, except portresses, female gate-keepers, and sanitary employés, can enter the service of the company without previous examination by a company's physician, who gives him a certificate declaring the state of his general health and degree of his corporeal fitness for the particular position desired. The system of examination adopted by the Northern Railway Company of France is especially commendable. Any degree whatever of organic heart trouble, or any predisposition to tuberculosis, is cause for rejection. Particular attention is given to integrity of vision (with special reference to color-blindness), to freedom from varicose veins and hernia, among all men applying for train service—such as conductors, engineers, firemen, brakemen, and also switchmen, road-laborers, and shop-operatives. The ocular sense is examined by inspection of the eyelids, the lachrymal ducts, the conjunctiva, the cornea, and the pupil; by comparing the *visual field* of the candidate with that of the examiner; by determining *visual acuteness* by means of Snellen's test-types; by testing the *chromatic sense* with colored worsteds. (In the last case no one is condemned without re-examination by the physician-in-chief.) The sense of hearing is tested by the distance at which the ticking of a watch can be heard.

The list of ailments which are made absolute causes of rejection, or relative causes of disrating actual employés, comprises no less than sixty-eight affections. Six are cutaneous, including leprosy, lupus, and syphilitic ulcers. Four are maladies of the nervous system—convulsions, delirium tremens, paralysis, and insanity. Eye disorders number twelve, among which are myopia, color-blindness, and cataract. Well-marked deafness is the only ear-trouble specified. Affections of the neck comprise wry-neck, scrofulous and cancerous tumors, goitre, chronic laryngeal troubles, etc. Maladies of the thoracic walls (four in number) have reference to diseases of the bony structure; among those of the respiratory organs are included pulmonary consumption, chronic catarrh, and asthma; of the heart, we find organic affections of the walls, valves, and pericardium, and aneurism. There are six abdominal ailments, and eight of the genito-urinary organs, but not all of the last involve total disability. Constitutional infirmities include the scrofulous, scorbutic, tuberculous, and cancerous taints, and natural feebleness. From the above it appears that the examination partakes of the nature of that of recruits for the army and navy, and of that for life insurance, and on the whole is rather more searching than either. Its importance is apparent, when it is considered that the company assumes grave responsibility for the lives and health of its servants, while it thereby secures the permanent service of picked men, far above the average in efficiency and lasting qualities. The advantages to the men of the medical service, after admission to the company's employ, are so manifold (in relief, surgical and medical, in provision for the misfortunes of age and disability, and in permanence of engagement) that they are correspondingly attached to the company, and perform their duties with a fidelity not otherwise attainable, and a skill only acquired by long practice. At the same time risk of strikes, reprisals, and suits for personal damages is eliminated, as is also that of such accidents as are attributable to defects of the special senses and to sudden failure of vital organs on the part of those concerned in the movement of trains.

RELIEF.—Every employé, including females not examined, is entitled to relief (both attendance and medicines) in case of injury or sickness, except under circumstances hereafter to be mentioned. Whenever anyone declares himself ill, or is reported absent by reason of sickness, his foreman gives to him, or sends to the district physician, a ticket of attendance, detached from a record-stub, and joins to it a pass over the road, in case the patient is not near the physician's station. The physicians receive these patients at the station-house or at their own offices. They record upon a case-book the names, occupations, and residences of the out-patients, the nature and cause of their sickness, the remedies prescribed, the expected duration, and, after cure, the actual duration of disability for work; adding such observations as they deem useful to the patients and to the service. This record is examined by the physician-in-chief at every tour of inspection, and facilitates and governs future reference by the administration. When an employé, reported sick, is unable to leave the house, the ticket of attendance, inscribed "at domicile," with its precise location, is despatched to the physician, who then attends the patient at his own residence. In case hospital treatment is thought advisable, the patient has the option of home treatment at his own expense. On discharge from treatment the employé has his condition authenticated by the district physician to his foreman, without which the company is not responsible for the expense incurred. In a case of severe illness or injury, a company's physician may ask the counsel or aid of his colleagues in adjoining districts; or in emergency may call on a private medical man; but an account of the same must be rendered to the physician-in-chief.

An employé has the option of attendance by a private physician at his own expense. In an emergency certified by the man's foreman, when the company's physician cannot attend him, the private physician's bill is to be approved by the foreman and the district physician, and addressed to the physician-in-chief, who refers it to the administration. In any case, all such claim for fees ceases from the moment the company's physician is ready to attend the patient.

Medical and pecuniary relief for sickness or injury is limited to three months. After this the administration decides upon extending or discontinuing relief, or fixing

a time beyond which the employé goes out of the company's service. Every patient who exceeds his leave of absence without his physician's authority, or who unnecessarily requires the physician's attendance at his domicile, or is not at home when visited, is regarded as absent without leave and subject to penalty. The following are not entitled to medical relief: 1. Employés whose annual salary is more than twenty-five hundred francs. 2. Those who, though not required by the nature of their employment, dwell more than two kilometres from the establishments to which they are attached, in which case they can only require of the company's physician an authentication of their illness. 3. Those who, after discharge from attendance and before resuming work, again fall sick. 4. Those who were subjects of a chronic infirmity before entering the company's service. 5. Those whose illness results from their own misconduct (drunkenness, venereal infection, brawls, etc.). 6. Day-laborers and those working for contractors.

ACCIDENTS.—When an accident occurs upon the line, resulting in personal injuries, the physician of that district, and in his absence or in case of need those of the neighboring districts, and even private physicians, are summoned by telegraph to render aid, and, if necessary, organize an ambulance service. The company's physician will attend injured passengers until recovery, if they so desire. A circumstantial report of the accident is drawn up and transmitted to the physician-in-chief, and by him to the general manager. In an urgent case the foremen and employés are to follow the printed instructions concerning the first relief to be rendered while waiting for the doctor.

Whenever a district physician desires his place to be filled by one of his colleagues or by a private physician, he is to obtain permission of his chief. Each one is entitled to a free pass over his own and the two adjoining sections of the road, and the chief to a pass over the whole line.

MEDICAL STORES.—A relief-chest, with an amputation-case, a stretcher, and often a supply of medicines and surgical appliances, is deposited at the stations where workshops are located or locomotives are changed. Common relief-chests are deposited at other stations and establishments where they are liable to be needed. Purveyors of the company, such as apothecaries, druggists, surgical-instrument-makers, etc., agree to a written tariff of prices, and sell to employés of the company by the same tariff whatever articles they need for their personal use. All bills are presented quarterly to the district physicians, and after approval are transmitted to the physician-in-chief.

PRINTED INSTRUCTIONS TO EMPLOYÉS.—These relate: 1. To the principal hygienic precautions which should be observed by individuals to avert preventable diseases and accidents. 2. To the chief measures which are to be used on the spot while waiting for the doctor, in case of the most common accidents and maladies. 3. To the mode of employing the contents of the relief-chests and of the medicine-chests at the station-houses, especially those which are in daily use or can be obtained without a physician's prescription.

The Eastern Railway of France has some additional provisions, which are worthy of consideration, if not of commendation. All trains are provided with relief-chests, containing medicines and surgical appliances for use in case of accidental injuries to any persons travelling thereon. Sick employés continue to receive full pay during illness not exceeding eight days; from this time up to two months of disability for work they are allowed half-pay. Beyond two months the allowance is at the discretion of the administration. In case of death the company grants to the widow or orphans a sum equal to two months' pay, and assumes the expense of burial. In special cases further pecuniary relief to the family may be granted. But these allowances are made only to permanent employés. Day-laborers receive medical attendance and medicines, together with half-pay, during two weeks of disability, which may be extended if the disability arose strictly in line of duty.

A Provident Fund has been established among the people of this company for the purpose of supplementing the relief granted through the regular medical service, in case of sickness or injury, to employés or to their families in case of death. Its benefits accrue only to the contributors, and they receive half-pay for two months after the company's allowance has expired. In addition the family receive from the fund a sum equal to that allowed by the company. In case of permanent disability, besides allowances already mentioned, the invalid will recover all sums previously contributed by him to this relief fund; otherwise the relief is limited to one year's contributions. Relief can be refused when the disability has arisen from the person's own misconduct; and when he leaves the company's service no claim for reimbursement is entertained. Whenever the Provident Fund fails to meet all demands, the company advances the needed sum, and provides for repayment by increased assessment upon contributing members. Any surplus goes to the Pension Fund.

In France, the Netherlands, and Italy, the families of railway employés are not provided with medical relief by the railway medical service, but this is generally the case in Austro-Hungary, the German Empire, Sweden, and Spain. The regulations usually require employés to be contributing members to some association, and deductions are made from their monthly wages of one to two per cent. to the credit of the medical fund. This is supplemented by a contribution of a similar amount by the company—sometimes equal, and sometimes one-half. In the Austro-Hungarian Empire district-physicians instruct the men in the use of instruments, dressings, and certain medicines, so that they may know how to act in an emergency in the absence of a medical man, and how to assist him in case of need. In the German Empire station-agents and train-conductors are provided with printed instructions, and are required to familiarize themselves with bandages and simple dressings. In this country provision is made by the different companies for the care of those permanently disabled by sickness or injury while in the discharge of duty. In case of death their families are provided for. Certain classes of employés are also entitled to retire upon a pension, after service for a period of not less than ten years. Their widows are also entitled to a pension, and their young children to an allowance for their rearing. There are also regulations for the cleansing and disinfection of cars used for the transportation of live animals, as soon as emptied. All these regulations in the German Empire were drawn up by a government official, and have the force of law.

In the principal railway company of Northern Italy there are two associations of the employés which all are required to join, except those whose annual pay amounts to more than two hundred and forty dollars. One of these is for mutual assistance in case of injury or sickness, to which each member contributes one and a half per cent. of his monthly wages; the other provides retiring pensions after a fixed term of service, or in case of permanent invalidism, and calls for three per cent. of the wages. Want of space does not admit going into details in these pages. From the former, members receive during illness and convalescence, after one month's contribution, one-third of their wages; after two months' contribution, one-half; after three months' contribution, two-thirds of their wages. This relief terminates in three months, but may be renewed by decision of the committee, provided the state of the funds admits. In Sweden similar allowances of pay to sick and injured employés is made by the government railways; and some provision is made for their families in case of sickness, injury, and death, both by the companies and by their own associations.

In the United States a railway medical service first became systematized in 1869, on the Central Pacific Railway, and its plan has been imitated by other roads running through sparsely inhabited and extensive districts. A hospital was erected by the company at Sacramento, to the benefits of which all employés are entitled, and for

the support of which all have to contribute fifty cents a month. The Baltimore & Ohio Railroad has an Employés' Relief Association, to which all must contribute according to the amount of their pay. For this purpose they are divided into five classes; the lowest, receiving $35 and under per month, contribute one dollar per month, and are entitled to 50 cents a day during disablement not exceeding six months; while the highest, receiving $100 or more, pay five dollars a month, and receive $2.50 a day in relief. These figures apply to those employed in train service; in other branches the contributions and benefits are one-fourth less. After six months of disablement the allowance for relief is reduced to one-half. In case of death from accident, the legal representative is entitled to an allowance of from $500 to $2,500, according to the monthly contributions; in case of death from ordinary sickness, the allowance is one-fifth of the above. The company has no hospitals of its own, but has contracts with hospitals at the principal cities, to which its people may be admitted on favorable terms. The association pays for surgical attendance at the hospital, and the member for his board, which is more than met by his relief allowance. The company, at the beginning, appropriated $100,000 as a foundation to the relief organization, the interest of which is annually available. The salaried officers consist of the secretary of the association, who is the medical superintendent, and seven inspectors, who are assigned to specified districts, which they are constantly traversing to investigate cases of disability, the sanitary condition of the company's establishments, etc. They also attend persons injured by the casualties of traffic, both employés and passengers, make physical examination of applicants for employment, vaccinate those requiring it, and provide appropriate remedies for the relief of such disorders as malarial fevers and intestinal irregularities, wherever they may be found prevalent. There are also pension and building funds, to which employés may contribute at option and enjoy corresponding privileges.

Another system in use upon several American railroads has reference solely to relief, at the expense of the company, to sufferers from accidents, without provision for ordinary sickness. The only salaried officer is a chief surgeon. Contracts are made with local practitioners, at convenient intervals, to attend at fixed rates those accidentally injured. The district surgeons have free passes over their own territory, which is the most valuable consideration for the appointment. The Denver & Rio Grande Railroad, alone of American companies, provides relief-boxes for all trains, containing such medical and surgical supplies as are liable to be needed on the route. This company has its own hospitals, and requires a physical examination of all employed in the movement of trains.

It is evident that railway medical service in this country has nowhere attained the degree of efficiency and utility found on the continent of Europe. Probably the minuteness of details there exercised would be here found incompatible with American notions of personal liberty. There can be no dispute that an organized system of relief to sufferers from the casualties of traffic is demanded of all companies of respectable magnitude, as a measure of both humanity and economy. It is the cheapest mode of exoneration from legal responsibility to give all possible relief before it is demanded. When once this necessary provision is made, other desirable features can be added without great expense, making use of the same medical officers. There can be no doubt that sure relief to employés in ordinary sickness is a great advantage to them, and its appreciation conduces to such increase of content and fidelity on their part as to warrant a large outlay by a company to furnish a foundation for an organized system. The advantage is increased when the same privilege is extended to the man's family. It tends to permanence of engagements, and forestalls strikes and reprisals. The expense of this feature is met by deductions from monthly wages, which are cheerfully submitted to when the men find their advantage in the system. Physical examination of trainmen is required for the security of travellers from such accidents as are liable to result from defects of sight and hearing, and from sudden failure of vital organs; and, as a measure of protection to the relief-funds, it must be required of all who participate in its benefits. Relief-chests will not often be needed; neither are pocket-pistols; but, when occasion requires, both are urgently wanted. It is indisputable that certain intelligent employés ought to know how to use the contents of a relief-chest, and that they ought to be instructed by a medical man. Attention to the personal hygiene of employés, and to the sanitary condition of buildings, grounds, railway carriages, etc., is also a proper duty of the medical staff, and involves no expense comparable to its benefits.

It is evident that railways are liable, unwittingly, to become carriers of contagion, both of human beings and of animals transported in their cars, and that all reasonable means should be used to prevent so undesirable an event. Small-pox, cholera, and glanders may be mentioned as examples of such transportable diseases. Vigilant medical men in the service of a company would generally be able to give timely warning, so that the necessary precautions might be taken to keep infection at a distance; or, in case of actual admission of choleraic, variolous, or glandered subjects, that proper measures of disinfection might be employed. The prevention of such diseases is vastly more important than their cure, and in general the preventive functions of a railway medical service should be regarded as the most useful part of its duties. It is time now, near the dawn of the twentieth century, to recognize in medicine, as in an army and navy establishment, that its greatest achievements are in forestalling the ills which it was formerly expected only to redress. *S. S. Herrick.*

RAILWAY SPINE. This ambiguous and misleading term has been for many years applied to the large class of cases in which pain and stiffness in the back, and various symptoms referable to the nervous system, follow trauma in the form of blows, falls, and collisions. The name was given, and has come into general use, because railway accidents are among the most common causes, especially in those cases which come into prominence on account of litigation. The expression is ambiguous in that it gives no clew to the seat of the morbid process, as to whether the spinal cord, its membranes, its bony and ligamentous coverings, or the overlying parts, are affected; misleading in that it directs attention to the spinal cord, an organ which has probably far less to do with the trouble than has been generally supposed in the past. It should be premised that there is still considerable variance among those who have written on this subject, as well as in the prominent text-books. The views expressed in this article far from represent the unanimous opinion of authorities. They are, however, practically in conformity with the principles first enunciated by Page, to whom, more than to any other, is due the credit of rescuing the subject from utter confusion.

The symptoms under consideration follow accidents which cause a jar to the body, whether received from a blow on the trunk, head, or elsewhere, or from a fall upon the head, back, buttocks, or other part of the body. They generally vary in intensity with the violence of the jar, but in persons of neuropathic tendency the slightest possible shock may be the exciting cause for the most marked symptoms—a fact which lets much light on the pathology of the affection, in that it points, at least in these cases, to traumatic hysteria or neurasthenia, rather than injury to the spinal cord. The prevailing theory in the past, and perhaps even up to the present, has been that concussion of the spinal cord lies at the bottom of the trouble—a theory which has done much to perpetuate the name. This diagnosis, however, if ever allowable, is certainly, in the vast majority of these cases, not tenable.

Leaving out of consideration the symptoms arising from structural injury (hæmorrhage, myelitis, meningitis), which have been falsely attributed to concussion of the spine, but which should be sought under their appropriate titles, we find that the patients suffer, as a rule, first,

from more or less marked symptoms (which need not be here enumerated) of shock, and afterward, for a longer or shorter period, complain of soreness, pain, and stiffness in the back, and of the almost endless variety of nervous symptoms, which have been commonly accredited to spinal concussion. Included under this title have appeared not only such symptoms as pains in the back and elsewhere, loss of sexual power, general malaise, and weakness of the extremities, but also headache, sleeplessness, loss of memory, vertigo, inability to confine the attention, and similar symptoms, which would point rather to the brain than to the spinal cord, if any one part of the central nervous system were to be credited with the entire pathology of the disturbance. Recent writers (notably Page) have expressed great doubt as to the liability of the spinal cord to injury, as long as its bony case remains intact, although not denying that it may occur exceptionally. This view seems far more satisfactory than that of the writers who favor spinal concussion, when we consider the fact that the spinal cord, an organ of extremely light weight, hangs suspended in a cavity much larger than itself, the intervening space being filled out by areolar tissue, membranes, cerebro-spinal fluid, and a plexus of veins, all of which protect it in such a way that no ordinary blow is liable to affect it as long as the vertebræ are uninjured; furthermore, the automatic centres situated in the spinal cord represent a less delicate set of functions than those of the brain, and are, therefore, probably less liable to be thrown out of balance by a moderate jar. The brain itself, moreover, is mechanically so placed as to be much more susceptible to damage from violence than the spinal cord, being heavier and less thoroughly protected by its bony covering. On *à priori* grounds, therefore, we should expect the brain, rather than the spinal cord, to be the principal sufferer from a jar to the whole body, and the analysis of the symptoms, with this fact in mind, shows that the spinal cord is not even an essential factor.

Leaving for a moment the question of strain of muscles of the back, and of the ligaments of the vertebræ, which are frequently present in these cases, and which have perhaps been the principal factor in drawing attention to the spine, we find that most of the symptoms of so-called railway spine admit of satisfactory explanation by disordered function of the cerebral centres, and that they are closely allied to, if not identical with, the recognized symptoms of the functional nervous disturbances included under the names hysteria, neurasthenia, and hypochondria. Such symptoms as hopelessness, morbid fears, sleeplessness, mental irritability, and inability to confine the attention, certainly come under this category, as well as asthenopia, amblyopia, nervous deafness, and other disturbances of special sense. Among the other innumerable symptoms we find pains in the back, sensitiveness of the spine to pressure, weakness in the back, tenderness of the scalp, heaviness of the loins and limbs, flushes and chills, mental and physical hyper-sensitiveness, anæsthesia, and impotence. These are all recognized symptoms of functional nervous disease, and point to weakness and irritability of the entire nervous system, more especially the brain and the sympathetic, and the term spinal concussion, like that of spinal irritation, intended, as it undoubtedly often is, to convey the idea that disorder of the spinal nerve-cells, or of the meninges, furnishes the basis for the trouble, is certainly misleading. Sensitiveness of the spine to pressure has probably nothing to do with the cord in the large majority of these cases. The tender spots over the spine represent simply the ramifications of the sensory nerves of the region implicated, and it is a significant fact, in this connection, that these sensitive spots are common in the lower lumbar, sacral, and coccygeal regions, far below the termination of the cord. Apart from the sensitiveness of the tissues from sprain, these regions of hyperæsthesia fall into the same category as the tender spots on the scalp, pointing to cerebral irritability. The feeling of weakness in the back means, probably, that the muscles of the back are wearied in holding up the vertebral column, just as any other muscles may tire of performing their function, and we have no reason for connecting these sensations with the spinal centres. The same is true of the sense of heaviness in the loins and limbs, of which these patients often complain. Morbid fears, vaso-motor irregularities, and extreme sensitiveness to cold, heat, medicines, or other influences, may all be classed together as common to hysterical, hypochondriacal, and so-called neurasthenical patients. Such patients report the most severe symptoms following directly upon the application of cold water or electricity, or upon the exhibition of drugs in absurdly minimal doses. While these symptoms are by no means to be classed as simply imaginary, they are obviously to be explained by perversion of cerebral function. One of the most common symptoms complained of is loss of sexual power and desire, but this is not necessarily connected with the spinal cord, for the lower centres for erection and ejaculation are under the influence of the brain, so that this reflex may be started even by a thought or inhibited by a fear. Irregularities in micturition are frequently noticed, as well as palpitation, præcordial distress, and disorders of digestion differing in no respect from symptoms of functional vesical, cardiac, and digestive derangement met with in neurasthenia and hysteria. In some cases appear paralyses and contractures, anæsthesia, hyperæsthesia, and convulsions; the motor disorders not being limited, as a rule, to any muscle or group of muscles, but affecting a whole limb or more; the sensory disturbances being generally bounded by a line not representing the distribution of any particular nerve, and often affecting an entire half of the body (traumatic hemianæsthesia, first observed by Putnam). These conditions correspond with the typical motor and sensory symptoms of hysteria, the special senses being also generally affected in the manner characteristic of that disease (see Hysteria). Any or all of the symptoms enumerated under hysteria may be present, and need not be here recapitulated. It is true that these symptoms sometimes persist for a long time; this does not, however, militate against the diagnosis of hysteria, nor does their occurrence in men as well as women, to both of which facts Charcot has drawn special attention.

Apart from the neuralgic pains and hyperæsthetic spots on the back, the majority of the patients complain of constant pain and soreness in the back and sensitiveness to deep pressure over both the vertebral column and the muscles of both sides, most frequently over the lumbar regions. The pain is increased on movement, especially by bending and twisting the trunk. This symptom, whether accompanied or not by hypersensitiveness of the back to the light touch, points to strain of the muscles of the back, and sometimes of the ligaments of the vertebral column. It should not, therefore, though among the most persistent and troublesome of the symptoms, be attributed in any degree to disorder of the spinal cord or its membranes. A similar condition may obtain in the muscles of the neck and the ligaments of the cervical vertebræ, as well as in any part of the body which is liable to strain from either direct violence or muscular effort.

PATHOLOGY.—As to the exact pathology of those symptoms which are referable to the nervous system, we are still in the dark, as we are regarding the pathology of hysteria, neurasthenia, and hypochondria. Post-mortem examination reveals nothing, and we are forced to adopt the term functional disturbance of the central nervous system, regarding the brain as the organ most seriously implicated, without venturing to theorize as to whether the disorder is due to malnutrition, vaso-motor irregularities, molecular disturbances, or perhaps to reflex irritation from injury of abdominal or other organs. Certain writers (Westphal, Oppenheim) believe that chronic structural changes (widely diffused sclerosis) may supervene, and cause the persistence of symptoms sometimes seen. This matter must be considered as still under discussion. There can be no doubt, however, that atrophy of the optic nerve can follow simple concussion.

DIAGNOSIS.—The utmost care is necessary to exclude organic lesion of the central nervous system, as, for ex-

ample, hæmorrhage into the brain or cord, myelitis, and meningitis, as well as injury or disease of the vertebræ, especially fracture, dislocation, and caries. Before eliminating organic disease we should look carefully for such symptoms as local atrophy and coldness, rigidity, alteration of electrical reactions, ankle clonus, and irregularity of the pupils. Bed-sores and cystitis point to organic disease, and are practically never present in the class of cases here considered. When organic disease is demonstrated, the case should be classed and treated accordingly. Great care must be taken to exclude, as far as possible, simulation and exaggeration. The difficulty in detecting deceit is especially great on account of the ease with which the subjective complaints may be assumed and kept up. It must also be remembered that these patients may fall into a state of prolonged invalidism from simple lack of will-power, and even where no deceit is definitely planned the prospect of large damages naturally places a premium on inertia. We should always seek to discover, then, first—are the symptoms real, feigned, imagined, or exaggerated? secondly, if real, are they functional or organic? The variety of symptoms which may be feigned is so great that the study of their detection can hardly be entered upon in this article. Cases should be regarded with suspicion in which the symptoms have not appeared until the lapse of considerable time after the accident, allowing, however, a certain time for the patient to recover from the benumbing effects of the shock. Cases which appear to grow worse and worse up to the time of settlement of claims for damages should be examined with special care, and will often be found to improve rapidly after the claim is adjusted.

Treatment.—The treatment differs at the outset in no respect from that of shock, and later from that of strain, whether of muscles, ligaments, or both, and from that of hysteria, neurasthenia, or hypochondria, according as the symptoms of each disorder predominate. The treatment of these diseases is considered elsewhere.

Prognosis.—The prognosis of these traumatic functional disorders is better than that of similar disorders resulting from natural causes, and the tendency of the nervous symptoms, as well as that of the strain, is in general toward improvement, rapid or gradual, continuous or intermittent, according to the severity of the shock, the surroundings of the patient, and the various influences which govern the course of all functional nervous derangements. The previous condition of the patient should always be considered in making the prognosis, inasmuch as rapid and steady improvement is more to be expected in the case of a person previously robust, than in that of one already of a neurotic temperament or broken down by overwork, anxiety, or pre-existing disease. The exact period required for recovery can never be prognosticated; while the milder cases may run their course in days or weeks, others may last months, or even years, and in exceptional instances the symptoms, especially those referable to the back, seem to cause annoyance for an almost indefinite period of time, even when no question of damages or other inducement to invalidism is present. Permanency of the nervous symptoms is, however, of great rarity, excepting in persons already suffering from, or on the verge of, hysteria, neurasthenia, or hypochondria, where the trauma acts merely as an exciting or aggravating cause. It would seem that the prognosis which has found its way into the text-books, that these cases may grow worse and terminate fatally, has arisen from the old confusion between organic and functional cases. A prognosis which belongs, except in the rarest instances, only to the cases of organic lesion of the nervous system, should hardly be made to cover all indiscriminately. This prognosis accords an undue importance to nervous injuries resulting from railway and other accidents, inasmuch as in the vast majority of cases we have to do with such functional disorders as above described, either existing alone or in combination with strain of the muscles of the back and of the ligaments of the vertebræ.

G. L. Walton.

RÂLES. This term is applied to certain abnormal sounds heard in the chest. It is customary with many authors to speak of *dry* and *moist* râles. Sibilant and sonorous breath-sounds are called dry râles, although there is no more reason for calling these sounds râles than there is for applying the same term to cavernous breathing. Certain authors also call these forms of breathing rhonchi, and use the word râle to designate only the moist sounds. Rhonchus, again, by others, is used as exactly synonymous with râle.

The causes of these abnormal sounds vary considerably. We may have a considerable accumulation of exudation in the trachea and larger bronchi, producing large bubbles, or the smaller bronchi may be more or less filled, giving rise to small bubbles, or perhaps the sounds may be produced in the alveoli themselves. Râles may also be produced by the rubbing of roughened pleural surfaces, by the presence of fibrinous exudate on the pleura, and by the stretching of pleuritic adhesions.

Coarse Mucous Râles are coarse bubbling sounds produced in the trachea and larger bronchi. They are heard with both inspiration and expiration. They may sometimes be made to disappear for a time by causing the patient to cough. Sometimes, especially in children, they may produce a fremitus easily felt through the chest-wall. They are heard most commonly with acute bronchitis in its exudative stage, and with broncho-pneumonia, also with chronic bronchitis and phthisis, some cases of œdema of the lungs, lobar pneumonia, compression of bronchi or trachea due to neoplasm or aneurism, some cases of pleurisy with effusion, and empyema, especially with perforation of the lung.

Fine Mucous Râles are sounds of the same quality as the former, but finer. They are heard under the same conditions.

Subcrepitant Râles.—These are fine, high-pitched, bubbling sounds, heard during both inspiration and expiration. They may be produced by the bursting of small bubbles in the finest bronchioles or air-passages, or they may be caused by fibrin on the pleura, and by pleuritic adhesions. The cause of this râle has been a matter of considerable dispute. On the one hand, it is held that the sound is invariably produced in the finer air-passages; on the other, that pleural changes alone can give rise to it. The advocates of the former view hold that sounds resembling the subcrepitant râle may be produced in the pleura, but that a good ear can distinguish these from the true subcrepitant, by a slight difference in quality. Believers in the second dictum say that there is not enough motion of the air in the finer air-passages to give rise to the râle. Both of these views are extreme. There are cases in which the subcrepitant râle is heard which show, *post mortem*, nothing but pleurisy as a possible cause, and there are cases of œdema of the lungs, with no pleuritic changes, in which this râle has been clearly heard, and in which the serum in the lungs is the only demonstrable factor in its production. It cannot be denied that the sound may be due to either of these causes. This râle may be heard in pleurisy; bronchitis of the smaller tubes; broncho-pneumonia; lobar pneumonia during the stage of resolution, and occasionally during other stages; phthisis; and œdema of the lungs.

Crepitant Râles.—These are very fine sounds heard only at the end of inspiration, and sounding very near the ear. They occur in abrupt explosions. They are much finer than the subcrepitant râles, and are usually compared to the sound produced by rubbing a lock of hair between the fingers. The causes of this râle are the rubbing together of inflamed pleural surfaces, the entrance of air into ultimate bronchioles or alveoli, the walls of which are partly stuck together by exudate, or perhaps the breaking of very fine bubbles. Of these three possible causes the first seems most common, and it is not unlikely that this is really the only cause. It is conceivable that if the pleura be coated with a thin layer of sticky exudation, its surfaces will tend to stick together until the end of inspiration, and then, in slipping over one another, give rise to the sound. This râle is often said to be pathognomonic of acute lobar pneumo-

nia. This is not so. The râle is frequently heard in the first stage of this disease, but it is also heard in pleurisy, broncho-pneumonia, and phthisis. Taken in connection with a rational history of acute lobar pneumonia, the râle is of great value as a sign, especially if with it other signs be found, but it is not to be called pathognomonic.

PLEURITIC FRICTION SOUNDS are râles produced in the pleura when it is diseased. They may be of a rather moist, grazing character, or may be creaking and dry. They may be heard in all diseases in which the pleura is involved. As has been mentioned, the pleural surfaces, when diseased, may give rise to crepitant and subcrepitant râles.

PLEURITIC ADHESION SOUNDS.—In some cases of old pleurisy, with adhesions, peculiar sounds are heard, which may be accurately imitated by applying one end of a rubber band to the ear and stretching it. The adhesion sounds are probably produced by stretching of old adhesions.

THE METALLIC TINKLE is a sound resembling that produced by pouring water in drops into a bottle. It is produced either by drops of fluid falling from the roof of large cavities in the lung, or the cavity of hydropneumothorax, or by bubbles breaking in fluid under similar circumstances. In different cases one or the other of these causes may produce the sound. It is heard over some large cavities, and, in some cases of pneumo-thorax, may occur either when the patient speaks or with the breathing.

GURGLES are coarse râles which are more liquid than mucous râles. They are sometimes heard in bronchitis, in some cases of solidified or compressed lung, and in some cavities.

THE MUCOUS CLICK is a peculiar dry sound, occasionally heard at the end of inspiration. Its cause and significance are not clear.

DRY AND MOIST CRACKLES are sometimes mentioned. They are difficult to distinguish from subcrepitant râles.

SIBILANT BREATHING, sometimes called sibilant *rhonchus* or râle, is a whistling or hissing sound heard in cases where a bronchus is narrowed by inflammatory thickening of its mucous membrane or by other causes.

SONOROUS BREATHING is produced in the same manner as the former. It is of lower pitch and softer quality.

J. West Roosevelt.

RANULA, a cystic tumor in the floor of the mouth, formed by the dilatation of one or more of the acini of the anterior lingual glands (Ward[1]), known also as the "Blandin-Nuhn" glands (v. Recklinghausen[2]), situated at the under side of the tongue on either side of the frænum linguæ, near the apex.

This definition is founded on the result of a characteristically thorough investigation, by the accomplished Strassburg pathologist, of a typical ranula accidentally found at a necropsy made in his pathological institute. The cyst, about the size of a pigeon's egg, was found on the under side of the left half of the tongue, extending to a little beyond the median line upon the right side, and penetrating into the intermuscular spaces in different directions. The wall of the cyst was of a nearly uniform thickness of from one to three millimetres; the internal surface was nearly smooth, except in the upper part, where, anteriorly, toward the apex, there was a prominence of some five millimetres in height, upon which were two furrows; one of these, situated near the top of the prominence, allowed the passage of a bristle to the depth of two and a half millimetres, while the other, situated near the base and away from the apex, was impervious. The cyst was everywhere colorless and translucent, except at the inferior part, where there was an opaque spot of about twenty millimetres in diameter, of a brownish color, having at its edges two more cysts, each about the size of a pin's head. The ducts of the various salivary glands, Wharton's and Rivinus', as well as Bartolini's, were all to be traced outside of the cyst, having no other relation with it than proximity. The microscopic examination showed that the epithelial lining of the cyst-wall was in two layers, the inner one of ciliated cylindrical epithelium, and beneath this a layer of small polygonal cells with large nuclei. The cyst contained a clear, somewhat thick, glairy, and viscid mucus, faintly yellow in color. The morphological elements were cells of an epithelial character in various stages of "colloid" degeneration, large brownish granular bodies, and numerous hyaline corpuscles, among which were some quite large, of a diffused, faint greenish-yellow shade, permeated with countless "vacuoles." The chemical examination showed a considerable amount of mucus, but no evidence either of sulpho-cyanide of potassium or of any fermentative material for the saccharine conversion of starch; therefore the fluid was not saliva. This confirmed the investigation of Besanez,[3] made in 1845.

Ranulæ, in general, present themselves as translucent pink or bluish tumors, generally globular in shape and fluctuating, lying either wholly in the mouth or between the mouth and chin, according to their size. They project into the floor of the mouth from beneath the tongue, at first quite to one side of the frænum linguæ; but as they grow to fill the mouth they elevate the tongue, push it over to the opposite side, and in time present themselves against the teeth in front, and may even prevent their closure. They push the frænum toward the opposite side, but may project beyond it, giving the appearance of two tumors, or of one tumor divided into a larger and a smaller portion. With this filling up of the mouth the interference with speech and deglutition is very great. The elder Cline[4] relates the case of a person who was in great danger of immediate suffocation by a large ranula which thrust the tongue back into the fauces. When not interfered with the tumor will project in the neck below the angle of the chin, and fluctuation may be felt in this situation. When the tumor is large the deformity of expression is great, and presents a certain resemblance to the mouth of a frog, the pale bluish, translucent hue adding thereto; hence the name, from *rana*, frog (*Froschgeschwulste*, Germ.; *grenouillette*, Fr.).

Cysts of other organs than the Blandin-Nuhn glands are also found in this situation. Wharton's duct may be dilated by the damming back of the secretion of the submaxillary gland from the formation of a salivary concretion in the duct, either at its orifice or in its course, and dermoid cysts, often of considerable size, are also found. The latter are especially interesting pathologically, as they undoubtedly represent here the remains of a fœtal organ which normally entirely disappears. The branchial fissures of the fœtus are normally obliterated early in fœtal life, but occasionally a fold of the tegumentary or epiblastic layer becomes included in the deeper tissues in the process of closing in from the sides to form the face, and finally becomes entirely separated from its attachment to the external skin. It may remain quiescent, giving no evidence of its presence, or the cells of the epithelial lining may be excited to growth and the interior become filled with the products, consisting of broken-down epithelium, fat, cholesterin crystals, and débris, *i.e.*, the usual contents of cysts developed from the dermoid layer. Indeed, hairs, bone, and teeth have been found in them.[5] These dermoid cysts, however, do not spring from the same point as do true ranulæ. They are situated either in the median line, between the two genio-hyo-glossi muscles, or between one of these and the mylo-hyoid; but as they grow they extend upward into the floor of the mouth, or downward in the neck, as far, perhaps, as the larynx.[6]

DIAGNOSIS.—These various tumors present points of differentiation sufficiently marked, usually, to allow them to be recognized, and as the treatment of each is different, it is important to have them well in mind. The positions of true ranula and the dilated Whartonian duct are, by the time they have aroused sufficient attention to be brought to the notice of the surgeon, very nearly the same; they both lie just under the tongue, to one side of the frænum, and filling up the floor of the mouth, elevating the tongue above it, and appearing as a thin-walled, fluctuating, and translucent tumor. In the case of the ranula, this tumor has upon its surface

Wharton's duct, the orifice of which can usually be detected near the median line, and into which a fine probe or bristle may be passed, and seen to glide along the surface to the submaxillary gland, external to and beyond the cyst. Careful search will often, also, reveal the orifices of the sublingual gland, the ducts of Rivinus. Blood-vessels are frequently seen coursing in waving lines over the cyst. When Wharton's duct is the seat of the tumor, the entrance of the probe into it will be prevented by the obstacle blocking it up, be it salivary concretion or inflammatory product, and removal of the obstacle will usually allow the escape of the fluid. In these cases there are usually considerable pain and circumjacent swelling, with other evidences of inflammatory action in all the parts implicated; the floor of the mouth is hot and tender, the tongue is painful on motion, and under the jaw the submaxillary gland is swollen and tender.

The clinical features of the dermoid cyst are different; indeed, there should be no confusion between them, but inasmuch as, from their situation and gross appearances, they are sometimes described as ranula, it is well to point out their differences. The wall is usually thick and firm, the contents may be quite thick, even mortar-like, sometimes purulent, or the contained fluid may be thin or viscid. There may be fluctuation, but it is less distinct than in ranula, and the surface often pits on pressure. The tumor is situated more deeply under the muscles of the mouth, and, when presenting under the jaw, is imbedded among those of the neck, and may penetrate even as far down as the larynx. In the mouth it arises nearer the median line, although as it grows its origin becomes obscured, and may not be readily determined at the time that the case comes under the observation of the surgeon.

Treatment.—No other than operative interference is of any avail in the treatment of these cysts, and it is usually necessary to do more than simply to evacuate their contents. If it be a dilated *Whartonian duct*, the removal of the concretion blocking up the orifice is usually sufficient; but this requires some care, as it is often very brittle, and if any fragments remain they set up a good deal of irritation in the duct itself, and serve as nuclei for further collections. Therefore, an opening should be made in the duct sufficiently large to "shell out" the stone entire. As these are occasionally quite long, it may require a considerable incision in the length of the duct, but this is preferable to making a small opening and endeavoring to drag the stone out; for if this is attempted it is liable to break, to the subsequent annoyance of both patient and surgeon. It is better, when practicable, to remove the *dermoid cyst* entirely, though, when it extends deeply and has very firm attachments, this will be difficult, and may be impossible with safety to the patient.

When not large it is usually easiest to make a free incision through the cyst-wall—whether in the mouth or under the chin depends upon its accessibility—and evacuate the contents. When these are thick and tenacious this may be a matter of some difficulty. After this, the cyst-wall being tolerably firm, it will bear considerable dragging upon, and may be enucleated with the handle of the scalpel, aided by occasional snips with the blade or with scissors. Cases are occasionally met, however, in which the operation of entire removal is both difficult and dangerous. In Mr. Mayo's[6] case the tumor extended down nearly to the clavicle, passing between the sterno-mastoid muscle and the trachea. After scooping out the contents and removing a part of the wall, he left the rest to suppurate, first filling the cavity with lint soaked in turpentine, in order both to arrest the hæmorrhage and to hasten the suppuration. The patient recovered after a considerable time.

Sir William Fergusson's[7] case filled the mouth so as to threaten suffocation, keeping the teeth forcibly apart and projecting prominently under the chin. He feared to leave "a sac so large and thick to the certainty of a violent inflammation," . . . and "resolved instead to attempt the extraction of the whole cyst." Incisions were made both in the mouth and in the neck, but "the sac was so amalgamated with the surrounding tissues that a free use of the knife was required." No large vessel was cut, but there was much loss of blood both at the operation and subsequently; the ultimate result, however, was entirely satisfactory.

The true thin-walled ranula requires a different treatment. Simple incision is not sufficient, for the edges of the wound usually reunite and the cyst forms again. The wall is also too thin to allow its enucleation *in toto*. A seton introduced through its walls, and allowed to remain a couple of weeks, more or less, will sometimes, but not always, cure it, and is to be tried first. This failing, some surgeons recommend the removal of a large part of the thin wall, in the expectation that the remainder of the cyst will collapse and the walls unite, to the obliteration of its cavity; but, like the seton, this often fails. A sort of plastic operation has, therefore, been tried, and is usually successful. This consists in forming a triangular flap by a couple of converging incisions in the anterior wall, and fastening the apex by two or three sutures to the opposite wall; adhesions are thus formed, and the cyst is kept open until the wall shrivels up. Sonnenberg recommends that the remainder of the gland be dissected out of its bed in the apex of the tongue, thus preventing the development of any other cysts afterward. This is occasionally done, with very satisfactory results, when milder measures have failed.

W. H. Carmalt.

[1] Ward, Nathaniel: Article Salivary Glands, in Todd and Bowman's Encyclopædia of Anatomy and Physiology, vol. iv., pt. 1, p. 426.
[2] V. Recklinghausen: Virchow's Archives, Bd. 84, p. 425.
[3] Besanez, Dr. Goruss: Heller's Archiv für Phys. und Patholog. Chemie u. Microscopie, vol. ii., quoted by Dr. Owen Reis in the article Saliva, in Todd and Bowman's Encycl. of Anat. and Phys., vol. iv., pt. 1, p. 420.
[4] Chelius' System of Surgery, vol. iii., p. 121. Edited by J. F. South. Philadelphia, 1847.
[5] Butlin, Henry S.: Diseases of the Tongue, p. 239. Lea Brothers & Co., Philadelphia, 1885.
[6] Mr. Mayo, of Winchester, England: Lancet, 1847, i., p. 667, quoted in Druitt's Surgery, p. 423. Philadelphia, 1860.
[7] Fergusson's Practical Surgery, p. 445. Philadelphia, 1853.

RAPE-SEED, OIL OF. (*Oleum Rapæ*, Ph. G.) This is a nearly non-drying oil, obtained from several cultivated varieties of *Brassica* (order, *Cruciferæ*), related to turnips and cabbages, and extensively raised in Europe for their seeds, from which it is extracted by pressure.

Rape-seed, or colza, oil, is a thick, yellowish liquid of no very characteristic odor or taste. It is extensively employed as a lubricant, as a salad oil, and as a cheaper substitute for olive-oil generally. In this country its place is taken by cotton-seed oil. Purified, it is put to cheap uses in German pharmacy, such as in making liniments, plasters, etc.

Allied Plants.—Turnips of various sorts—summer, winter, rutabaga, etc.; cabbages, cauliflower, Brussels sprouts, and kohl-rabi; also mustard and radishes. For the order see Mustard.

Allied Drugs.—All the fixed oils; see Olive-Oil.

W. P. Bolles.

RASPBERRY. (*Rubus Idæus*, U. S. Ph.; *Framboise*, Codex Med.) The fruit of the garden raspberry. *Rubus Idæus* Linn., order, *Rosaceæ*, is a well-known European straggling shrub, cultivated both there and here for its delicious fruit. It has not the slightest medicinal value, and is only used in syrup, etc. (*Syrupus Rubi Idæi*, U. S. Ph.), as a pleasant vehicle, or a flavor for aërated waters, etc. The leaves of raspberry are a household astringent, like blackberry root, etc.

Allied Plants.—The leaves of *R. fruticosus* Linn. are in the Codex (*Ronce Sauvage*). They are astringent. See Roses, Blackberry, etc.

Allied Drugs.—Fruits and fruit-syrups in general.

W. P. Bolles.

RAVENDEN SPRINGS. *Location*, Ravenden Springs, Randolph County, Ark.

Access.—By the St. Louis, Iron Mountain & Southern

Railway (Missouri Pacific System) to O'Kean, then by stage.

ANALYSIS.—One pint contains:

	Grains.
Carbonate of magnesia	0.560
Carbonate of lime	0.576
Carbonate of lithia	0.157
Chloride of sodium	0.273
Chloride of magnesium	0.373
Chloride of lime	0.155
Sulphate of lime	trace
Sulphate of alumina	0.295
Silica	0.103
Iodine and iron	trace
Organic matter	0.232
Total	2.724
	Cub. in.
Carbonic acid gas	2.68
Atmospheric air	1.66

THERAPEUTIC PROPERTIES.—These are mild alkaline waters, sufficiently charged with natural carbonic gas to render them very agreeable.

The springs are situated in the northeastern part of Arkansas, in a picturesque country abounding in game and fish. *G. B. F.*

RAWLEY SPRINGS. *Location and Post-office,* Rawley Springs, Rockingham County, Va.

ACCESS.—By the Baltimore & Ohio (Harper's Ferry & Valley Branch) Railroad to Harrisonburg; thence by stage to the springs, ten miles.

ANALYSIS (Professor J. W. Mallet).—One pint contains:

	Grain.
Carbonate of magnesia	0.085
Carbonate of iron	0.203
Carbonate of manganese	0.002
Carbonate of lime	0.055
Carbonate of ammonia	trace
Carbonate of lithia	trace
Chloride of sodium	0.005
Sulphate of potassa	0.014
Sulphate of soda	0.068
Sulphate of lime	0.013
Alumina	0.005
Silica	0.085
Organic matter	0.036
Loss	0.073
Total	0.644
	Cub. in.
Carbonic acid gas	0.77

THERAPEUTIC PROPERTIES.—This is said to be the best chalybeate spring in Virginia.

Rawley Springs are situated in Northwestern Virginia, on the southern side of North Mountain, amid beautiful scenery and salubrious air. *G. B. F.*

REACTION OF DEGENERATION. When a muscle is cut off from its centre of innervation it undergoes changes, among which is its susceptibility to the influence of electrical excitation. The alterations are known as *quantitative* and *qualitative,* with reference to the degree of contraction, and the variations in it respond to the interruption or closure of the current. Muscles which are paralyzed, there being total suspension of innervation, at the end usually of two weeks begin to undergo a change, when faradic (induced) currents produce no response, and the action under the galvanic current is reversed. The healthy muscle responds most vigorously to cathodal (negative) closure; while in well-established degeneration the anodal reactions of both kinds seem to cause the most lively contraction. In the unaffected muscle the healthy reaction would be as follows: *

$$\begin{array}{l} \text{Ca Cl C} > \text{An Cl C} \\ \text{Ca O C} < \text{An O C.} \end{array}$$

* The symbols used in the formulæ are the following:

D.R. = Degenerative Reaction.	Ca = Cathode.
An = Anode.	Cl (or S) = Closure.
O = Opening.	C = Strong contraction.
c = Medium contraction.	Tc = Tetanic contraction.
> = greater than.	< = less than.

As the process of degeneration advances we first find that the anodal closing contraction is equal to the cathodal closing, and that the anodal opening contraction is equal to the cathodal opening, but as the degeneration becomes confirmed we find the formula expressed:

$$\text{D.R.} = \text{An Cl C} > \text{Ca Cl C}; \ \text{An O C} < \text{Ca O C.}$$

Ultimately it is impossible to get any response whatever, except perhaps a weak anodal closing contraction. When such an advanced degree of degeneration exists the muscle undergoes atrophic changes, and its essential elements, more or less, disappear, while fatty deposit takes place. If the abolition of conductivity is not too extreme, or does not last too long, we find after a time an inverse restoration, the muscle responding feebly at first to an interrupted galvanic current of great strength, the normal reaction being finally attained, and afterward faradic excitability. For the electric diagnosis of the reaction of degeneration we should make use of a milliampère metre, and begin with a minimum current which may afterward be increased. If it requires a current of several milliampères to evolve a response, we may measure the qualitative improvement by the reduction in the required strength and note the same. Small carbon electrodes covered by absorbent cotton are the best. I have of late dispensed with cell selectors, and use simply a water rheostat and a milliampère metre.

Allan McLane Hamilton.

RECOARO, near Valdagno, in Venetia, is a pleasantly situated spa, lying in a sheltered valley at an elevation of about 1,500 feet above the sea. The climate is mild. There are ten or more springs in the place, the most important of which are the Lelia, Amara, Lergna, Giuliana, Civillina, and Virgiliana. The first four of these are the property of the government. The following is the analysis (made by Ragazzini) of two of these springs, computed in parts per thousand:

	Fonte Lelia.	Fonte Giuliana.
Calcium sulphate	1.310	trace
Calcium carbonate	1.016	0.100
Ferrous carbonate	0.069	0.063
Magnesium carbonate	0.099	0.051
Sodium sulphate	0.045	0.010
Magnesium sulphate	0.679	0.451
Magnesium chloride	0.004	0.003
Silicic acid	0.017	0.009
Organic matters, etc.	0.022	0.013
Total	3.261	0.700

The waters of Recoaro are given chiefly internally, though baths are also employed to a certain extent. They are recommended in the treatment of anæmia, in convalescence from typhoid fever and other debilitating diseases, in catarrhal troubles of the digestive and urinary systems, and in the visceral congestions following rebellious malarial fevers. The season extends from May to the middle of September. *T. L. S.*

RECTO-VAGINAL FISTULA. A communication between the rectum and vagina. In rare instances an opening is established between the vagina and some higher part of the intestine, oftenest the lower part of the ileum. A coil lying in the Douglas pouch may become adherent, and ulcerate or rupture into the vaginal cul-de-sac.

SYMPTOMS.—The escape of fæces and intestinal gases into the vagina and from the vulva. In some cases, when the edges of the fistula are ulcerated or cleanliness is neglected, vaginitis and vulvitis result. Then the patient suffers from itching, soreness, and offensive discharge. In sensitive natures this distressing infirmity induces depression of spirits, amounting sometimes to melancholia. The severity of the symptoms depends, however, on the size of the opening and the state of the bowels. If the opening be small, the diet properly regulated, and the parts kept clean, all the symptoms will be greatly mitigated.

CAUSES.—These may be classed under two heads—mechanical violence and disease.

Mechanical Violence.—All forms of difficult or instrumental labor in normal or deformed pelves; the use of forceps and the exercise of undue manual force; cephalotripsy; slipping of blunt hook, or other instrument used in the reduction of the size or extraction of the child; laceration by splinters of the bones of the fœtus. Contraction or other deformity of the bony pelvis, as from tumors, exostoses, and anchylosis of the coccyx; and a narrow or indistensible condition of the vagina, strongly predispose to this injury during labor. Certain operations, such as those for the relief of stenosis or atresia of the vagina; extirpation of tumors of the uterus or vaginal walls; excision of cancer of the rectum; and perforation of the rectum from rough or unskilful administration of enemata are occasional causes. Pessaries, when ill-fitting or neglected, sometimes ulcerate into the rectum, though much more rarely than into the bladder. Recto-vaginal fistulæ following labor are usually the result of lacerations; more rarely they result from prolonged pressure causing a slough with perforation.

Disease.—Cancerous, syphilitic, or other ulceration not rarely results in perforation of the recto-vaginal septum. Abscesses of the septum, from whatever cause, may rupture into both rectum and vagina. Suppuration of an adherent pelvic dermoid, or other ovarian tumor, or of an extra-uterine gestation-sac, may establish a fistula between rectum and vagina. The latter causes lead especially to the formation of fistulæ communicating with the upper part of the vagina.

Recto-vaginal fistula is very rare except in adults, but is not unknown even in infants. Bednar relates a case of gangrene of the recto-vaginal septum, resulting in fistula, in an infant of four weeks. This child died of cellulitis of the right arm. Witter relates another in a child of seven months, who had suffered from thrush for several months, when suddenly fæces began to escape from the vagina, and an ulcerated opening was found in the recto-vaginal septum. A healthy wet-nurse was procured, and with the addition of local cleanliness and the use of carbolized glycerine tampons to the vagina, the child recovered perfectly.

The course and duration depend on the cause and mode of origin, and the extent of the opening. A fistula from cancer usually grows larger, and there is no hope of cure. Syphilitic or other ulceration may heal and cicatrize partially, or even completely, and a spontaneous cure result. The latter result is probably rare in syphilitic ulceration, but more frequent in the simple forms. Perforating lacerations, and sloughing of the septum leading to fistula, in many cases get well by attention to cleanliness and by securing to the patient influences which improve general health. A few weeks may thus suffice to close a good-sized opening. Winckel saw an opening of the size of a dollar close in a fortnight. Spontaneous healing may be retarded or entirely prevented by cicatricial bands, which prevent the edges from coming together. Subsequent labors may result in enlargement of the opening, or in its closure, or leave it uninfluenced.

DIAGNOSIS.—This is usually a simple matter. Women suffering from the symptom called by German writers garrulitas vulvæ, in which air entering the vagina in certain positions, and escaping, it may be with noise, on changing position, or even without, during the movements of the pelvic floor synchronously with the movements of the diaphragm, are often in great distress of mind from imaginary fistula; but the gas thus escaping is odorless, being merely atmospheric air. The symptom is due to some defect of the forces which maintain intra-abdominal pressure. The accessibility of both vagina and rectum to examination by finger and eye through the speculum, renders diagnosis an easy matter. Except in the case of very small or remote fistulæ, examination by means of one finger in the vagina and another in the rectum, assisted it may be by probe or sound, at once discovers the opening. If very small, the speculum may be necessary. The injection of milk or some other colored liquid into the rectum will speedily reveal the opening in the vagina as the fluid escapes through it.

TREATMENT.—In cancer this is hopeless. In other forms of ulceration the first steps must be taken in the direction of securing cicatrization of the ulcer by the necessary constitutional and local measures. Until these measures have been tried operation is inadmissible. Recent lacerations, if discovered, must be immediately stitched, and the prospect of success is as good as in the immediate suture of lacerated perineum. If the lesion be not discovered in time, or if the primary operation fail, the parts on both sides of the opening, rectal and vaginal, must be kept clean, and stimulated if necessary, in the hope that spontaneous closure may result. This, we have seen, is by no means rare. In any case the size of the opening will certainly be much reduced. Vaginal tampons impregnated with glycerine and carbolic acid may assist. The bowels must be regulated, and accumulations of masses of hardened fæces in the rectum prevented. For the cure of chronic recto-vaginal, as for all other chronic fistulæ, two principal methods have been resorted to—cauterization, and suture after denudation.

Cauterization is comparatively easy of application, but very uncertain in its results. It is useless for large openings, and almost so for small ones, if the septum around the opening be thin. Most of the strong caustics, as well as the actual cautery, have been used. Solid nitrate of silver, nitric acid, and the acid pernitrate of mercury afford a list from which to choose. The whole extent of the fistula, from the vaginal to the rectal opening, must be cauterized. Dieffenbach's method was to cauterize a ring around the vaginal opening of the fistula with silver nitrate, and a few days later to apply the actual cautery to the vaginal opening and whole extent of the fistula. The galvano-cautery is better for this purpose than the Paquelin cautery, because it need not be heated till it is in contact with the surface to be cauterized. If the cautery fail after a trial or two, it is better not to repeat it, as the edges of the opening will be rendered cicatricial, and therefore in a less favorable condition for the success of the inevitable operation.

Denudation and Suture.—There are few cases which in skilled hands cannot be thus cured. More than one operation may be necessary, and in complicated cases various modifications of that suitable to simple cases may have to be resorted to. For the success of this, as of all plastic operations, it is essential that the general health be good and that the parts concerned be in a healthy condition. Two or three days immediately before the operation will be well spent in dieting and purging, especially with calomel and soda aided by salines. The diet had better consist of beef juice, well-boiled wheat flour porridge and milk, stale bread or toast, and, once a day, underdone tender mutton chops. Immediately before the operation both vagina and rectum must be thoroughly well washed out, and then irrigated with a 1 to 3,000 corrosive sublimate solution. The operation may be done through either vagina or rectum. The vagina is always selected when practicable, and the cases are very few in which it is not. The whole circumference and extent of the fistula should be freshened in such a way as to secure as broad surfaces as possible for apposition. This is to be done by making the opening funnel-shaped, the denuded surface at the vaginal opening being of greater extent than at the rectal opening. The rectal mucosa is to be interfered with as little as possible on account of its greater vascularity. The parts will be most effectually exposed for operation by placing the patient on her back and flexing the thighs on the pelvis, the anterior vaginal wall and labia being kept out of the way by retractors—those known as Simon's being the best. The direction of the line of sutures must be determined by approximating the edges with tenacula and observing that in which there is the least tension. Any cicatricial bands on the vaginal surface which prevent approximation must be freely divided, by knife or scissors, at some distance from the edges of the opening. The material of the suture may be fine silver or other sufficiently flexible metallic wire, carbolized silk, catgut, or silkworm gut.

Success may be attained by using any one of these, but most operators, probably, prefer silver wire, as it can so easily be secured by twisting in a cavity like the vagina. A variety of needles have been used, but the simplest appears to be Emmet's—a short, slightly curved needle held in the jaws of a needle-holder. It is threaded in such a way that a long loop of silk is made to draw the wire sutures into position. The needle is entered on the right or upper side (as the case may be) of the vaginal opening, at least half a centimetre ($\frac{3}{16}$ in.) from the denuded edge, and made to traverse the tissue of the septum and emerge just at the edge of the rectal mucosa. It is then carried across the opening to the other side, entered at the rectal edge, and brought out on the vaginal surface at the same distance from the edge of the freshened surface as on the opposite side. Five or six sutures to the inch will be necessary. The most exact coaptation possible of the raw surfaces must be secured, but the sutures must be drawn tightly enough to secure contact only, without strangulation. This last is the error most apt to be committed by inexperienced operators. The diet for the first three days should consist of animal broths, jellies, and gruels, with very little milk or other food which leaves a solid residue in the intestines. The bowels had better be allowed to remain undisturbed for three days, and then moved by a five-grain dose of calomel at bedtime, followed next morning by a saline laxative, such as a seidlitz powder, a teaspoonful of Epsom salts in a large glass of warm water, or a dose of Hunyadi or Friedrichshall mineral water. Soon after the saline is given, an enema of from two to four ounces of a warm solution of ox-gall must be cautiously thrown into the rectum. This will soften any hard masses which may have accumulated, and so prevent injury to the line of union during the evacuation. The bowels are to be moved every day, for at least a fortnight, by salines and the ox-gall enema. After the bowels have acted, some tender meat, bread, and light pudding may be added to the diet-list, but vegetables are to be withheld for a week longer. The sutures are to be allowed to remain for eight or ten days. The only objection to the method described, so generally successful, is that, if it fail, tissue has been removed, and this may prejudice the chances of success by subsequent operation. To obviate this objection various modifications have been practised. One is to dissect up a frill of vaginal mucosa in the form of a circle around the opening, and turn it into the rectum. The sutures are to be applied to both vaginal and rectal openings, the rectal ones being of catgut; or the edges of the fistula may be split, rectal and vaginal sutures being employed. When the fistula is low and near the sphincter ani, failure of the operation is more common than in the upper part of the septum. This is due to the disturbing action of the sphincter. In such cases success may be more certainly assured by dividing the whole of the tissues, sphincter muscle included, from the fistula, through the perineum, freshening the edges of the fistula, and then closing the wound as in the operation for complete laceration of the perineum. In certain other cases in which the recto-vaginal septum is very thin, the method of raising a flap of vaginal mucosa, sliding it over, and attaching it all round to the freshened edges of the opening, may be the best operation. *W. Gardner.*

RECTUM, MANUAL EXPLORATION OF THE. In 1872 Professor Simon, of Heidelberg, published, in the *Archiv für klin. Chir.*, an article "On the Artificial Dilatation of the Anus and Rectum for Exploration and Operation," in which he first described a method of exploring the lower bowel by the introduction of the entire hand. By this method of examination, he asserted that not only was he able to explore all of the pelvic organs, and to distinguish any pathological changes they might have undergone, but that the greater part of the abdominal cavity could also be reached. He further asserted that this method was so entirely free from danger that he had not hesitated to practise it on patients anæsthetized for other purposes. He thus describes the procedure: "The hand being well oiled, two fingers are at first introduced through the sphincter, then four, and finally the thumb and whole hand. The dilatation must be gradual, and assisted by a rotatory motion; and, if these directions be followed, a hand measuring twenty-five centimetres (nearly 10 in.) may be introduced absolutely without harm.

"The anus forms, in its greatest dilatation even—which is twenty-five centimetres in circumference or more—a narrow entrance to the larger cavity of the rectum. This cavity is formed by the inferior and middle portion of the rectum, the first of which lies outside of the peritoneum, and the second is covered only on the anterior portion by the posterior wall of Douglas' pouch, and extends to the superior third of the rectum, *i.e.*, to a point above which the peritoneum encloses the anterior and lateral walls of the bowel, and where it is attached to the os sacrum. This point lies from twelve to fourteen centimetres above the anus, and corresponds to the third sacral vertebra.

"The greatest width of the rectal cavity is at a point from six to seven centimetres above the anus, and its expanding capacity here is from twenty-five to thirty centimetres. From this point to the superior extremity of the middle third it gradually diminishes to from twenty to twenty-five centimetres, and from here it rapidly lessens until, in the middle of the upper third, it is not more than sixteen to eighteen centimetres in circumference, its narrowest portion being in the sigmoid flexure. The base of the thumb is thrust as far as to this point, twelve to fourteen centimetres above the anus, and half the hand can advance through the upper part of the rectum into the beginning of the sigmoid flexure. Therewith the abdomen can be palpated several centimetres above the umbilicus."

Simon thus limits the depth to which the hand should penetrate to the upper part of the rectum and lower part of the sigmoid flexure, and only claims to be able to palpate the abdomen somewhat above the umbilicus. Subsequent experimenters have not been satisfied with these limits, and have asserted that the hand could be made to enter the descending colon. This can readily be shown, on the cadaver, to be a physical impossibility. Nussbaum, in attempting to explore a supposed diaphragmatic hernia, reached the ensiform cartilage.

Later and more extended experience with this method has made it necessary to modify very materially the conclusions reached by its author. Many times disastrous consequences have followed its application, and not infrequently diseased conditions which were present have entirely escaped detection; we are forced, therefore, to the conclusion that it is necessarily attended with dangers which cannot be foreseen or guarded against, and that it is very much less successful as a method of exploration than was at first supposed.

This modification of opinion is manifested in late writers, who, like Koenig, admit the dangers and limit the method to very exceptional cases, or Follin ("Pathologie Externe," 1883), who speaks with reserve about the entire procedure. Furthermore, most of the general surgeries, and some of the special works on rectal diseases, ignore the subject entirely.

With the increased freedom with which exploratory laparotomy is now practised in the diagnosis of doubtful abdominal affections, the field for manual exploration by the rectum is certainly very materially limited.

The introduction of the hand into the rectum, even where the limits set by Simon were strictly observed, has been followed by incontinence of fæces, which, however, has generally disappeared in a few days. In other cases a fatal result has quickly ensued. The writer, some years ago, collected five fatal American cases, and the number since then has greatly increased. In the fatal cases the muscular coat of the bowel has alone been torn in some, and in others the peritoneal covering. In a case that came under my own observation the rupture of the peritoneal coat was evidently due to abnormal narrowing of the bowel from an abscess in the walls.

In one case an aneurism of the cœliac axis was found ruptured on the death of the patient, which occurred on the following day. In some cases the patients seem to have succumbed to shock.

In many cases this means of exploration unquestionably facilitates the exploration of the pelvic, and part of the abdominal, cavity.

Small tumors on the posterior aspect of the uterus have been discovered and their relations determined; the ovaries have been fully explored; the anterior surface of the sacrum has been examined and limited caries detected; and psoas abscess has been with certainty diagnosticated. The size of stone in the bladder, it is said, can be accurately mapped out, and stricture of the rectum has been explored.

But with so much success attesting the value of this means of exploration, it has not infrequently failed to discover stricture, even when as low down as the lower part of the sigmoid flexure, and has failed in the detection and attempted reduction of inguinal hernia. From the recorded experience of manual exploration of the rectum we can fairly conclude that its value has been exaggerated, and the dangers which attend it not duly appreciated; so that we feel justified in the conclusion that as a means of exploration it is allowable only in very exceptional cases. *N. P. Dandridge.*

REDRESSEMENT FORCÉ. A procedure introduced by Delore, of Lyons, in 1874, for the immediate correction of the deformity of knock-knee. His method is as follows: The patient, being anæsthetized, is placed upon the side, the deformed member resting with the trochanter upon the table, and the external malleolus raised about four inches above it. The surgeon now makes direct pressure in a vertical direction upon the affected knee, forcing it down by a series of jerks until the external condyle touches the table. A peculiar crackling is heard during the operation, which is caused by the giving way of the bony and fibrous tissues of the articulation. The acquired position is maintained by a starch bandage. The normal function of the joint is said to be restored at the end of about six months. A modification of this operation has been proposed by Tillaux, in which the limb is placed with the inner condyle resting upon the edge of the table, the thigh is steadied by an assistant, while the surgeon seizes the leg and forces it down until its axis corresponds with that of the femur. An instrument has been devised by Collin, similar in construction to the osteoclast, which effects the reposition of the deformed member by means of a long lever and the compound pulley. Redressement forcé is not an operation to be commended. It is a dangerous procedure, inflicting an amount of traumatism upon the joint that is liable to excite very intense inflammation, jeopardizing the utility of the limb, or even the life of the patient.

Thomas L. Stedman.

RED SULPHUR SPRINGS. *Location and Post-office,* Red Sulphur Springs, Monroe County, W. Va.

ACCESS.—By the Chesapeake & Ohio Railway (Newport News & Mississippi Valley Company) to Lowell, thence by stage to the springs, twelve miles. From the South by Norfolk & Western Railroad to Adairs, thence by stage.

ANALYSIS.—One gallon contains (Hayes):

	Grains.
Silicious earthy matter, containing traces of oxide of iron and ammonia, probably suspended merely..	0.70
Sulphate of soda, in a dry state (which forms with the water. 802 grains)	3.55
Sulphate of lime	0.47
Carbonate of lime (lime dissolved in carbonic acid)..	4.50
Carbonate of magnesia (magnesia dissolved in carbonic acid, and forming the "fluid magnesia")..	4.13
A peculiar substance, containing sulphur combined with organic matter	7.20
	20.55

Gaseous contents of a gallon, or 231 cubic inches:

Carbonic acid	5.750
Nitrogen	6.916
Oxygen	1.201
Hydro-sulphuric acid	0.397
	14.264

THERAPEUTIC PROPERTIES.—This water is remarkable as containing an "azotized base combined with sulphur," which Dr. Hayes pronounces new and peculiar. It is claimed that under this form the sulphur is readily absorbed. The reputation of this spring as a "cure" for pulmonary diseases antedates the recent treatment of tuberculosis by enemata of sulphuretted hydrogen, and there is good reason for believing that the water has often proven efficacious in those affections.

Red Sulphur Springs is situated in the southeastern portion of West Virginia, on Indian Creek. The ride from Lowell is through picturesque scenery and forests of pine, over an excellent road. The hotel, having accommodations for four hundred guests, is located in a valley thirteen hundred feet above sea-level. The property contains fourteen hundred acres, and possesses every variety of mountain scenery. There is excellent hunting and fishing in the surrounding forests and streams.

Geo. B. Fowler.

REFLEX ACTIONS, or **REFLEXES,** constitute a highly important and fundamental group of the phenomena displayed by animals, and although they are usually executed by muscular or epithelial tissues, and are oftenest observed in the form of motion or secretion, they are, nevertheless, wholly dependent for their peculiar characteristics upon the nervous system. Roughly speaking, they are distinguished by the fact that the immediate stimulus to the "action" lies outside the central nervous system, and yet, in a round-about way, works through it so that the nervous impulse or disturbance produced by the stimulus upon the periphery of the body, or elsewhere outside the central nervous system, travels first centripetally into that system, and then centrifugally out from it to the parts which finally execute the "action." The path described by the nervous impulse in its passage in and out resembles so plainly that described by the sound waves in an echo, or by a ray of light reflected from a mirror, as to suggest immediately the term *reflected*, or *Reflex actions*, or *Reflexes* for phenomena so peculiar and characteristic. But it cannot be too often repeated that this interesting analogy between the path of a nervous impulse in a reflex action and the path described by light, sound, etc., reflected from surfaces, is only an analogy; for while in the latter case the thing reflected is precisely like the thing impinging, and departs at definite angles, under rigid physical laws which are well understood, there is good reason to believe that the incoming nervous impulse in a reflex action of the animal body is unlike the outgoing impulse, which is certainly not merely a reflected portion of the former, but something different from, and often disproportionate to it, elaborated and sent forth by the central nervous system acting under the influence of the incoming impulse just received—doubtless in accordance with rigid physical laws, yet laws which are virtually unknown.

The parts of the mechanism involved are, primarily, the *stimulus* or *excitant*, which is the cause; and next, the sensitive end-organ (*a*) upon which the stimulus works until it has produced a nervous impulse (*b*), which travels along a nerve or nerve-fibre, the afferent or sensory nerve (*c*), by which the impulse is conveyed inward to the central nervous system—the brain or spinal cord. In a special portion of this central system (and oftenest in the spinal cord, which is in great part a special organ for this function), the impulse appears to be worked over in a reflex centre (*d*), from which after a time a new nervous impulse (*e*) is forwarded along another nerve or nerve-fibre, the efferent or motor nerve (*f*), which conducts the impulse to a nerve-ending or end-organ (*g*), which thereupon so stimulates the humbler muscular or epithelial tissues with which it is connected that these (*h*) execute the visible acts called reflexes. The whole group of events, from (*a*) to (*g*) inclusive, must, therefore, be regarded as in some sense the *effect*, of which the stimulus is the *cause*. Yet it should not be forgotten that this "effect" is largely influenced by other conditions, some of which will be mentioned hereafter. The ordinary observer, of course, witnesses only the beginning and the end of the action, although he may generally

perceive that considerable time has elapsed between the application of the stimulus and the reaction. This is known as the *reaction-time*, and that portion of it which is spent in the reflex centre (*d*) is known as the *reflex-time*.

Examples of reflex actions are abundant and familiar, as, for instance, the movements and laughter produced by tickling; coughing due to an irritated throat; vomiting from an irritant (stimulus) in the stomach, or a foreign body in the fauces. Light falling on the retina is the stimulus which leads to reflex movements of the iris, and (in many persons) to sudden sneezing. A finger unwittingly brought against a hot object, such as a stove, is almost instantly withdrawn, even without the help of volition. The legs of a decapitated frog, provided the spinal cord be still intact, are drawn away from acid or mechanical stimuli, and perform movements, almost purposeful in appearance, to wipe off bits of acidulated paper laid upon the flanks. The act of winking is a reflex mechanism, as are also the secretion of the digestive juices, some of the movements of the different portions of the digestive apparatus which convey the food to the rectum, the secretion of saliva, known as the "watering" of the mouth at the sight or smell of appetizing food, the flow of tears, the secretion of sweat from fear, etc.

Over against these REFLEX, or "reflected," actions must be put the AUTOMATIC actions of the animal body (such as volition, the beat of the heart, etc.), whose source is not immediately discoverable outside the central nervous system, or which arise within it. This division of nervous actions into the two great groups of "reflex" and "automatic" actions is the modern one. Before it was adopted physiologists maintained that many actions, such as eating and drinking, walking, talking, and the like, were purely voluntary; others, such as the beat of the heart, the peristaltic movement of the intestine, the flow of saliva and the other juices, the motions of the iris, etc., being purely involuntary; while still others, such as the respiratory movements (ordinarily done involuntarily, but capable of control to some extent, as when we sit with "bated breath"), winking, coughing, sneezing, etc., seemed to be of a mixed nature, being ordinarily free from the help or hindrance of the will, yet sometimes subject to its influence. This view was the one generally held in the last century, as, for example, by Dr. Robert Whytt, F.R.S., who, in the Introduction to his essay upon "The Vital and other Involuntary Motions of Animals" (1751), says: "Physiological writers have divided the motions of animals into voluntary, involuntary, and mixed. The voluntary motions are such as proceed from an immediate exertion of the active power of the will. The involuntary and mixed motions (which last, though subject to the power of the will, yet are not ordinarily directed by it) may be aptly enough comprehended under the general denomination of *spontaneous;* since they are performed by the several organs, as it were, of their own accord, and without any attention of the mind, or consciousness of an exertion of its power. Such are the motions of the heart, organs of respiration, stomach, intestines, etc., which have been also distinguished by the term *automatic;* though perhaps there is an impropriety in the word, as it may seem to convey the idea of a mere inanimate machine, producing such motions purely by virtue of its mechanical construction; a notion of the animal frame which ill agrees with the inertia and other known properties of matter."

As is foreshadowed in the latter portion of this quotation, the view stated in the former part has been somewhat changed since that time. The study of reflexes, which has been greatly extended along lines begun in part by Whytt, together with more exact studies of biology in general, and, especially, of the animal organism as an isolated mechanism acted upon by an environment external to itself, and by it reacted upon in its turn, have led to most interesting and fruitful conceptions of the physiology of the nervous system. Instead of voluntary, involuntary, and mixed actions, physiologists for the most part now agree to consider every action as aroused by some definite cause or stimulus. Stimuli proceeding directly from the environment, and provoking reactions upon it, plainly produce reflex actions. Stimuli arising within nerve-centres, and acting directly upon and through the centres in which they arise, produce automatic actions. Stimuli arising within the organism (it may be in nerve-centres), and acting upon nerve-centres other than their own, must clearly produce reflex actions, since the event differs essentially in nowise from an ordinary reflex action. If, for example, it could be shown that the heart-beat depends directly upon the pressure of blood upon the endocardium, or upon the quality of that blood, or upon any other stimulus affecting the cardiac ganglia from without, we should be forced to regard the heart-beat as a reflex act. But until some such evidence is forthcoming we are obliged to consider it automatic, self-regulating, spontaneous. In the same fashion, whenever it is proved beyond doubt that the activity of the respiratory centre depends wholly upon the oxygenation of the blood, we shall be obliged to regard it as a reflex centre; and there is a very considerable amount of evidence already pointing in that direction. Finally, it must not be overlooked that modern physiology, in using the word "automatic," or self-regulating, applied to a nerve-centre, does not regard automatic powers as either the result of chance, or as having arisen, by a kind of spontaneous generation, *de novo*. The powers and properties in any automatic centre to-day were either inherited (after having been acquired more or less remotely), or were acquired, being repeated until they became fixed in what we call habit. In the infant, talking is at first chiefly echo, imitation, and "reflexion," more or less perfect. Judgments, also, of distance, time, position, and the like, are chiefly the resultants of childish experience often repeated and blending with an inherited background, in which they grow and become more easily fixed or transformed into habits; and even actions apparently the most automatic or spontaneous, viz., those of the kind called voluntary, not seldom have their origin in remote impressions, or are directly modified by sensory impulses. Thus the acts of walking, talking, eating, etc., usually go on without the direct supervision of the will; and even the orator's words, chosen it may be beforehand, are delivered in a modified manner according to impulses arising from the picture of his audience upon his retina. Even the most characteristic beliefs, ideas, and desires of the most original minds are largely, if not almost wholly, the delayed or postponed resultants of earlier impressions acquired and inherited—reflexes infinitely elaborated and modified in the reflex or automatic centres, or having a very long "reaction-time."

Thus it appears that in comparison with complex automatic actions, ordinary reflex actions, which in their simplest forms are merely reactions upon an acting environment, are the simplest of all—the units, from the addition and multiplication of which we have reason to believe that the higher forms of action—automatic actions and even volition—are in great part compounded. That classification, therefore, of nervous actions into reflex and automatic, which is now almost universally adopted and to which we shall adhere, is evidently warranted more by convenience than by any marked fundamental differences between them.

GROWTH OF OUR KNOWLEDGE OF REFLEX ACTIONS.—The great body of facts relating to reflexes forbids an enumeration of all of them, but the more important principles thus far established and underlying their physiology, may be easily apprehended by reviewing the historical development of the subject. Here we are fortunate in being able to refer, even for the smallest details, to the work of Eckhard, whose extensive and laborious history of reflexes appeared in 1881. From this the following historical data have been chiefly, and often literally, taken (C. Eckhard: "Geschichte der Lehre der Reflexerscheinungen," *Beiträge zur Anatomie und Physiologie*, Band ix., Giessen, 1881).

Many reflexes had been observed, of course, long before any of them were understood. Sneezing, tickling, and coughing must have been always familiar to everybody. Moreover, it had not escaped notice that stimuli often

produce effects in parts remote from the point of application. Thus, "Hippocrates has observed that the unexpected sight of a serpent will make the countenance pale. The sight of grateful food occasions an uncommon flux of the saliva in an hungry person. When one eye is affected with an inflammation or a cataract, the other is often soon after attacked with the same disease. A bright light coming suddenly on the eyes sometimes occasions sneezing. We shut both eyelids, whether we will or no, as often as anything threatens to hurt either eye. The contraction of the pupil is not owing to light acting as a stimulus on the iris, but solely to the sympathy between this membrane and the retina." This quotation from the "Works of Robert Whytt, M.D.," Edinburgh, 1768, p. 495, indicates well some of the reflex actions which were then familiar, and also (in the last sentence) introduces us to the then prevailing theory of *physiological sympathy*, which was the forerunner of the modern doctrine of reflex actions. To Whytt belongs in large measure the honor of showing that "sympathies" are effected through the central nervous system; and that he held very advanced views appears, *e.g.*, from the following: "Cold water thrown on any part of the body that is warm produces a sudden contraction of the whole vessels and pores of the skin. . . By doleful stories or shocking sights delicate people have been often affected with fainting, etc., and, although in these cases the changes produced in the body are owing to the passions of the mind; yet, as the mind is only affected through the intervention of the optic and auditory nerves, they seem proper enough instances of the general sympathy that extends through the whole nervous system" (*loc. cit.*). Much, however, had been learned long before the time of Whytt. Hippocrates has been quoted already, as having noted the blanching of the face from fear, etc. Galen was aware that closure of one eye causes the pupil of the other to dilate, although he did not know of any other motions of the pupil, and attributed this "dilatation of the pupil of the open eye to its having the spirits which used to be bestowed on both eyes now determined into it alone" (*loc. cit.*). Explanations like this were to be expected before the discovery of the circulation of the blood, or the establishment of the fact that the arteries are not air-tubes. In fact, we learn from Whytt that at the beginning of the sixteenth century "Achillinus makes particular mention of the motion of the pupil from different degrees of light; which, however, was so little attended to that its first discovery has been generally ascribed to Father Paul, who lived about a hundred years after him. However, neither Father Paul nor Fabricius ab Aquapendente seems to have known how these motions are performed" ("Whytt's Works," p. 61).

With the seventeenth century a change began, although theories and arguments rather than proofs still held the day. Among the authors of that time Descartes comes first. He dwells upon the subject in two separate papers, viz., "Les Passions de l'âme" (1649), and "Tractatus de Homine" (1677). In the former he points out that involuntary movements may be evoked, without affecting consciousness, by the most unlike sensory nerves and the brain; this, too, in some groups of muscles rather than in others. As an example, he cites the involuntary shutting of the eyelids, and other movements which we unconsciously and involuntarily make for defence from threatened danger. It is interesting to learn, moreover, that he considers as the central organ, or seat of transfer of sensory to motor impulses—not the brain or spinal cord, but—the pineal gland, long regarded as the seat of the soul, but now known to be non-nervous in nature, made up of a mesh of blood-vessels, and probably representing the rudiment of a third, unpaired, and median eye. In this connection Descartes spoke of the impulse as "reflected." The second paper is interesting chiefly because it shows Descartes' clear comprehension that these events occur without the participation of the "soul."

Swammerdam, in his "Bibel der Natur" (1652), refers to the involuntary movements which men and the lower animals, especially when sleeping, exhibit whenever their skins are gently irritated; and says that they occur without any great participation of the will, yet attempts no explanations. Willis, on the other hand, in 1664, was not only familiar with many genuine reflex phenomena, but gave of them explanations similar to those given today. He mentions the involuntary placing of the ears, the involuntary cries, etc., of animals to which auditory impulses come, and compares the whole event in each case to an "echo." Willis regarded the brain as the "centre" of such physiological echoes, although he believed that the transfer of the impulse from the sensory to the motor nerves takes place also through peripheral anastomoses.

In the seventeenth century experiments upon decapitated animals were also known, and although explained otherwise than they are to-day, and not brought into line with the observations just recorded, they are of great interest as being the earliest examples in experimental physiology which prove that *in brainless animals movements can be evoked by stimuli.* Toward the end of the century physiologists generally seem to have been familiar with such observation as that of Boyle, described by himself as follows: "The body of vipers may be sometimes, two or three days after the skin, heart, and head, and all the entrails are separated from it, seen to move in a twining or wriggling manner, nay, may appear to be manifestly sensible of punctures, being put into a fresh and vivid motion when it lay still upon being pricked, especially on the spine or marrow, with a pin or needle." Yet it was only in the next century that physiologists pushed the analysis further. At this time they had, however, established the important fact that beyond the domain of a will conditioned by the presence of the brain, there must exist somewhere in the body a source of orderly muscular movement.

The question whether or not these movements are accompanied by consciousness does not seem to have attracted much attention as yet, although, as we shall see, it afterward assumed great prominence. Some, indeed, like Boyle, recognized the two possibilities, viz.: first, that the sensorium reaches down into the spinal cord, so that the latter is conscious by itself alone, as well as when joined normally to the brain; or, second, that all parts of the body may be potentially conscious or "independently perceptive," consciousness being diffused throughout the body, and not confined strictly to the brain, or brain and spinal cord. An experiment which we now know to be misleading, seemed to point to the first explanation. It was observed that decapitated frogs do not merely pull back their legs on being irritated, but also crawl and leap in a manner closely resembling the normal. This is indeed true in some cases, especially if the decapitation is done by scissors, one blade of which is put in the back of the mouth—in which case the optic lobes are generally only partially, if at all, removed—or if any large portion of the medulla be left connected with the cord. But if the *whole* brain, including the medulla oblongata (which was then usually reckoned as a part of the spinal cord), be taken away, the crawling or leaping movements never appear. The frog squats flat upon the belly, and is unable to do other than simple, purely reflex, movements.

In the eighteenth century more rapid progress was made. The chief place of "transfer" (*Uebertragung*) of the sensory to the motor nerve, or, as we will henceforth designate it, "the central reflex organ," was finally settled, after much debate and experimentation, which constantly brought new facts to light. Regarding the central reflex organ (which, as has been insisted above, is not a mere shunt or reflecting organ (p. 151), two hypotheses had arisen, viz.: first, the suggestion of Willis, that the peripheral anastomoses and sporadic ganglia are such reflex centres; and, second, that the brain and spinal cord (central nervous system, often called the *sensorium commune*) are the great central reflex organ—an idea held earlier by Descartes, etc. Of the first theory Vieussens was the principal supporter, although around him were grouped H. Boerhaave, Comparetti, Bergen, Walther, Vater, Buchner, Meckel, Gasser, Camper, and others,

chiefly anatomists. The only ground for this theory of the peripheral anastomoses lay in the argument (*post hoc ergo propter hoc*) that in the parts which stand in sympathy peripheral anastomoses occur in the nerves there distributed. Tissot ("Traité des nerfs et de leurs maladies," tome ii., pt. ii., Paris, 1780) has given a number of examples of this kind. The theory that the central nervous system is also the central reflex organ was defended by Perrault, Astruc, K. Boerhaave, Haller, Van Swieten, Monro, Marherr, Thaer, La Roche, Whytt, Tissot, and others; of whom Astruc, K. Boerhaave, and Whytt brought forward the most effective evidence for the theory and against that of the peripheral anastomoses. Astruc and K. Boerhaave affirmed (1) that there are sympathies where no anastomoses exist to regulate them; and (2) that even where there are anastomoses there is no genuine fusion of the nerve-fibres, which run parallel to one another into the central nervous system, and do not unite in the anastomoses, thus making "sympathy" in the latter impossible. It is not clear whether these bold (and certainly prophetic) statements were mere guesses, or based upon actual observation. Both these authors employ the word "reflexion," but not, as Cayrade would have it, for the first time. It had been used already by Descartes and Willis.

Most significant and fruitful of all was the work of Robert Whytt, to whom reference has been made above. Of him Eckhard well says: "R. Whytt is, in manifold ways, noteworthy in the history of reflex actions. We may grant that his conceptions of them were not exactly like our own, and yet find in his works a wealth of experimental discovery to which his predecessors did not approach in the remotest degree; containing in their infancy many principles of the physiology of reflexes which have only lately become the subjects of extensive research; besides a much more fundamental refutation of the 'peripheral anastomosis' theory than had been given by Astruc or anyone else; and finally, and perhaps most important of all, the first *experimental* evidence that the reflex movements of decapitated frogs are governed and elaborated by the spinal cord."

The more important discoveries of Whytt ("The Works of Robert Whytt, M.D.," etc. Published by his son. Edinburgh, 1768) may be summarized as follows: 1. It was known that decapitated animals exhibit movements upon being duly stimulated; it was suspected, urged, believed, and denied that the spinal cord is the central reflex organ, the seat of transfer of the impulse from the sensory to the motor nerve. Whytt *proved* that the *spinal cord* is the essential centre in such cases, by the simple but conclusive experiment of destroying it and then observing that movements afterward never ensue. Moreover, he frankly owns that the experiment was not wholly original with him, but done after the method of Dr. Stephen Hales, who, it will be remembered, was the first to take the blood-pressure by the manometer, and whose works on "Staticks" abundantly prove his ingenuity. "The late reverend and learned Dr. Hales informed me that, having many years since tied a ligature about the neck of a frog to prevent an effusion of blood, he cut off its head, and, thirty hours after, observed the blood circulating freely in the web of the foot; the frog also at this time moved its body when stimulated; but that, on thrusting a needle down the spinal marrow, the animal was strongly convulsed and immediately after became motionless" (*l. c.*, p. 290. See, also, pp. 284, 510).

2. Whytt was the first to point out that after decapitation the movements which are afterward easily evoked in such animals cannot be obtained till after the lapse of a few minutes. This is probably the first scientific observation of *inhibition*, and to it he added others (pp. 303, 501–502).

3. Whytt distinguished more clearly than had been done before him certain actions as reflex, the clear explanation of which was novel. We have mentioned above his reference to the "watering" of the mouth at the sight of "grateful food." This, of course, opened up the whole subject of reflex secretions. His theory of the reflex dilatation and contraction of the pupil is also noteworthy. "The pupil is contracted more or less in proportion to the quantity of light admitted into the eye, not on account of any immediate action of this subtile fluid on the fibres of the iris, as some have imagined, but in consequence of its affecting the tender retina with an uneasy sensation" (p. 62). "The contraction of the pupil when light offends the eyes, and of the eyelids when grosser bodies threaten to hurt them; . . . the copious secretion of tears and the saliva when stimulating substances are applied to the eyes or taken into the mouth. . . . These motions cannot, in my opinion, be referred to any connection or communication among the nerves, but to the brain itself" ("On the Sympathy of the Nerves," *l. c.*, p. 519).

It has been vigorously urged that Prochaska (1749–1820) is entitled to be regarded as the principal founder of the modern doctrines of reflex actions; but, in spite of the conflicting testimony, if we observe carefully the ideas, knowledge, and discoveries of Robert Whytt, we shall not greatly err, if we hold with Eckhard "that, aside from some few observations, Prochaska has neither discovered new facts or explained old ones, nor to any great extent advanced the theories of reflex actions" (*cf.* "Unzer and Prochaska on the Nervous System," Sydenham Society, London, 1851, esp. pp. 429–438).

Herbert Mayow showed, in 1823, more clearly than had been shown hitherto, that the reflex movements of the pupil depend primarily on stimulation of the optic nerve, and that the experiments succeed (in pigeons, with which he worked) even after decapitation, provided that the forepart of the crura cerebri, corpora quadrigemina, and the second and third pairs of cranial nerves are unharmed. This was perhaps the first experimental evidence of reflexes in heads separated from the rest of the body, and in the brain alone (*cf.* Herbert Mayow's "Commentaries on Physiology," ii., London, 1823).

The most prolific writer upon, and vigorous exponent of, the doctrine of reflexes that the nineteenth century has produced is undoubtedly Marshall Hall; and yet a comparison of his labors with those of his predecessors and followers, inclines us to agree with Eckhard, that it is very likely true that Marshall Hall made his first discoveries, and formed his earlier theories independently, and in ignorance of the work already done. Finding himself thereafter with a reputation to sustain, and differing somewhat from the older authors, he published copiously (perhaps rather than wisely), and without always giving full credit to his predecessors. Nevertheless, his services are very great and conspicuous, and his publications, reaching from 1832 to 1847, drew general attention to, and aroused great interest in, the whole subject. Hall was the first (unless Johannes Müller be excepted) to observe the rise of reflex irritability under opium and strychnine, and the fall under prussic acid; the first to observe the interesting fact that reflexes are more easily evoked through nerve-endings than nerve-trunks; the dependence of tonus upon the spinal cord, etc. He also proposed the hypothesis of a special "excito-motor system" distinct from the sensory-motor; the former to account for reflexes free from consciousness, and concerned chiefly with the spinal cord; the latter to explain the ordinary actions consequent upon sensation and volition. The hypothesis called for a double set of nerve-fibres going to all parts of the skin, but ending centrally, the one in the cord, the other in the brain.

Grainger sought to find an anatomical basis for this theory of Hall, and in his "Observations on the Structure and Functions of the Spinal Cord" (London, 1837), he claimed to have observed that, from the anterior and posterior roots of the nerves certain small threads proceed to the gray substance, while others enter the white substance of the cord, and then pass upward; accordingly, he assumed the former to be the "excito-motor;" the latter, those of sensation, perception, and voluntary movement. From the present standpoint of physiology it is interesting to perceive that, even so early as this, Grainger was led to conceive the gray substance of the

cord to be, in the last analysis, the principal central reflex organ within which the exchange from afferent to efferent impulses is effected. Grainger appears also to have been the first to formulate definitely the theory of the reflex function of the submaxillary ganglion in the act of salivary secretion; in which the afferent twigs are supposed to belong to the lingual, and the efferent to be branches (chiefly of the *chorda tympani*) from the ganglion. It was not new to regard the sporadic ganglia as reflex centres, however, for that was involved in the "anastomosis" theory. Indeed, Prochaska regarded the sympathetic ganglia as important reflex centres, and Le Gros Clark, a year earlier than Grainger, had done likewise. It is interesting to remark here that, as we shall see hereafter (p. 156), Claude Bernard, more than a score of years after Grainger, and, apparently, quite independently, took almost exactly the same ground regarding the function of the submaxillary ganglion, and adduced important experimental evidence which led to fresh researches, and to one of the most animated and fruitful debates in the history of experimental physiology.

Johannes Müller was working upon reflex actions at the same time as Marshall Hall, and in the first edition of his "Text-book of Physiology" (1833), gives the principal results of his labors. Unlike Hall, he was well acquainted with the history of the subject, although he seems to have overlooked the fact that the Hales-Whytt fundamental experiment had been repeatedly done already, and, like Hall, "discovered" it once more, apparently quite independently. He makes the usual statements about reflexes, gives the usual examples, and discusses thoroughly the sporadic ganglion question. In this he inclines to the belief that sporadic ganglia do not behave as reflex centres, but pronounces the question unsettled.

In 1833 Ehrenberg first published an account of the ganglion cells (in the sympathetic ganglia, and possibly in the cortex of the brain), (*Pogg. Ann.*, Bd. xxviii., 1833, p. 449). In 1837 Purkinje described them more clearly, in the brain and spinal cord, noting their processes or "poles," but not observing any connection of these with the nerve-fibres. Valentin, in 1839, proposed the hypothesis that these ganglion cells effect the transfer (*Uebertragung*) of the impulses in reflex actions, and are therefore the ultimate reflex centres. In 1846 R. Wagner and Robin (Wagner's Physiologie, Bd. iii., 2, 361) saw the ganglionic processes in direct connection with nerve-fibres, and Wagner suggested that the transfer is by a virtually continuous path—the three principal elements being the afferent nerve, the centre, and the efferent nerve.

From the time of Marshall Hall up to the present day so many workers have been engaged upon the physiology of reflex actions, that it is here impossible to do more than, with Eckhard, to follow out some of the lines of inquiry which seem most interesting, viz.:

1. The Methods of Study.
2. The Nervous Mechanism of Reflexes.
3. Inhibition of Reflexes.
4. The Time-Element.
5. The Effects of Drugs, Temperature, etc., upon Reflex Actions.
6. Laws of the Propagation of Reflexes.
7. Reflex Centres.

Methods of Study.—In passing from qualitative to quantitative studies of reflexes, it becomes necessary to measure and compare stimuli as causes, and actions as effects. The stimulus remaining the same, it has been found that the excitability of the reflex-apparatus varies with different circumstances, such as temperature, moisture, drugs, and, above all, the condition of the spinal cord. Or the apparatus being the same, different stimuli produce different effects.

The first successful attempt to secure precise results was by means of *chemical stimulation*, in a way since known as "Türck's Method" (Ludwig Türck, "Ueber den Zustand der Sensibilität nach theilweiser Trennung des Rückenmarks," *Zeitschrift der k. k. Gesellschaft der Aerzte zu Wien*, vii. (1851), 189). Türck's method consists in allowing the toes of a suspended frog to dip to a fixed depth in very dilute sulphuric acid. The time which elapses between the immersion of the toes and the pulling of them out by the animal—the *reaction-time*—is then taken as the measure of the excitability of the reflex apparatus. Türck used acid of one-fifth to four-fifths per cent., and found that in any one animal, the conditions remaining the same, the reaction-times are equal, especially if care be taken to wash off the acid promptly after the dipping of the foot. Setschenow added a useful feature to the method by introducing the metronome as a simple and convenient chronograph, and he, besides others, has employed the method without questioning its accuracy. Some, however, have alleged that with very great dilution of the acid frogs react only after longer and longer intervals. Still others maintain that the first reaction follows later (*i.e.*, after a greater interval) than in the succeeding trials. These and other disputed points in Türck's method have been carefully investigated by W. Baxt (*Berichte der König. Sächs. Gesellschaft d. Wiss.*, 1874, pp. 309–314).

According to Eckhard (*Beiträge*, etc., ix.), who has thoroughly reviewed the literature of the subject, three important considerations must be borne in mind, not only in this method of chemical stimulation, but in thermal and other methods described further on, viz.:

1. Very gradual increments of strength in an ineffective irritant will not always suffice to produce a reaction, even though they be continued until a greater strength has been reached than—otherwise applied—would prove to be a powerful stimulus; for it has been shown, especially by C. Fratscher (*Jenaische Zeitschrift*, N. F., ii., 1875, 30), that if we begin to stimulate by a solution of acid, alkali, etc., so dilute that no reaction follows, we may *gradually* increase its strength up to a point where actual destruction of tissue ensues, without once evoking a reaction. With hot water equally astonishing results were obtained, for Fratscher found it possible to heat slowly, not only decapitated, but even normal, frogs from the ordinary temperature until they passed into *caloris rigor*, without any reflex actions ensuing at any point of the process.

2. The reaction-time varies with the strength of the stimulus. In general, acids of the strength of the acids of the body, such as that of the gastric juice, are ineffective. Above this point, according to Baxt, while the concentration increases arithmetically, the reaction-times diminish geometrically.

3. For each individual there is a point where stimuli of a certain weakness will evoke (though barely) a reflex action. These stimuli are called *minimal stimuli*, and the point itself is called the *Reflexschwelle* or *reflex threshold*. If we overstep this threshold by still greater dilution of the irritant, no reaction follows; if we have been using ineffective stimuli, this marks the lowest point at which reaction begins.

Mechanical stimulation is probably the oldest, and yet the least trustworthy, method of evoking reflexes. The difficulty of making quantitative measurements by its means is, however, so great as to make other methods preferable. Here, also, increments of stimulation must be sudden and considerable, for it has been found possible even to crush a limb without ever provoking action, provided care be taken to make the increments of pressure small and gradual.

Thermal Stimulation.—Here too, as has been shown above, gradual increments are ineffective to evoke reaction. Heinzmann (*Pflüger's Archiv*, vi., 1872, 222 found that the increments, when a whole leg was immersed, must exceed $\frac{1}{250}$ to $\frac{1}{300}$° C. per second, otherwise the animal might pass motionless into *rigor caloris*. Foster (*Journal of Anat. and Physiology*, vol. viii., p. 45) found that if only the toes were immersed, it was impossible to pass, however slowly, above 35° C. without reaction; and explained the fact of easier reaction following the immersion of a smaller area by comparing it to the easier stimulation of a nerve through a bit of skin than through the whole nerve-trunk. Fratscher, however, finds it

possible to go higher than 35°; indeed, as high as is desired even with the smaller area. It has been suggested by Sedgwick (*Studies from Biol. Lab. Johns Hopkins Univ.*, ii., 385) that the greater difficulty of arousing reflexes by thermal stimuli, when larger areas are immersed, is due not so much to the stimulation of a large area as to the heating of the whole animal by the circulating blood to such an extent that the contrast between the part in the water and that out of it never amounts to enough to constitute a stimulus. That this is very likely true is shown by stopping the circulation at the beginning of an experiment; after which it is found that comparatively low temperatures produce movements, even when large areas are immersed.

The question has been raised whether the reflexes produced by various stimuli are produced through the same end-organs. Türck, who first introduced the subject, takes the affirmative. Setschenow (Setschenow und Paschutin, "Neue Versuche," etc. Berlin, 1865), and Danilewsky (*Archiv für Anat. und Physiologie*, 1866, p. 677) take the negative, the latter holding that a difference exists between "tactile" and "pathic" reflexes. The subject cannot be further treated here, but it may suffice to say that the present tendency appears to be toward the idea of a (limited) number of end-organs, rather than of one kind susceptible to all sorts of stimuli.

Electrical Stimulation.—The same general statements may be made here as in the other cases of stimulation. The constant current is effective only when of a certain strength; but summation may occur and give rise to stimulation, in the use of streams so weak as to be ineffective, by making the current interrupted. Induced currents at rather long intervals may be of considerable strength, and yet produce no reactions; while weaker but more frequent currents may be "summated" and produce reactions. This whole subject has been accurately studied by Stirling ("Berichte der Königl. Sächs. Gesellschaft der Wissenschaften," 1874, p. 372), who carried out his investigations in Ludwig's laboratory, and employed novel and exact apparatus. Reference must be made to his complete paper for the details.

THE NERVOUS MECHANISM OF REFLEXES.—Since the time of Mayow, Hall, Müller, and Grainger (*vide supra*), there has never been any doubt that the brain acts as a central reflex organ. It does not appear to act as a whole, but the cerebrum and cerebellum seem rather each to include many centres. The spinal cord, however, is the central reflex organ *par excellence*, not so much from the great number of reflex centres located in it (for it must be remembered that the extreme hind-brain—the *medulla oblongata*—is very rich in reflex centres), as from the fact that this is probably its most important function, while the brain, including the medulla, is much devoted to other important functions. It must not be forgotten, however, that the hindmost portion of the spinal cord does not act as a central reflex organ, as was first shown by Volkmann (Müller's Archiv, 1838, p. 15; 1841, p. 354), and has since been confirmed. Thus Sanders-Ezn (1867) affirms that no reflexes can be obtained from the cord of a frog behind the level of the eighth pair of spinal nerves. Koschewnikoff states that all reflexes cease upon removal of the cord as far back as the middle of the fifth vertebra. Eckhard finds that even strychnized frogs showed no reflexes with the hindmost portions only of the spinal cord intact.

It is no longer held by anyone that reflexes occur according to the old doctrine of the peripheral anastomoses. When, however, we turn to the question whether or not the sporadic ganglia can serve as reflex centres, we find a mass of conflicting testimony, and great difference of opinion. It may be said, meanwhile, that although the possibility that they may so act is granted, no sufficient proof has yet been given that they do or do not. At the same time it cannot be denied that if they do act as reflex centres some evidence of the fact ought to be easily obtained; and, on the other hand, it is not difficult to see the advantages which must accrue to that organism whose central government is instantly and directly informed of changes occurring in its periphery. It is much easier on *à priori* grounds to suppose internal, and, so to speak, domestic affairs, such as the heart-beat, vaso-motor actions, and the like, to be partially self-controlled, automatic, or even purely reflex, than more external affairs, such as locomotion, motion, secretion, etc., which are far more irregular and unequal. In the latter the advantage of a central co-ordinating apparatus in direct communication with every part of the body is too evident for debate. That this central system should reserve direct reflex authority over the periphery, and surrender to internal machinery the general control of vaso-motor actions, etc., is also quite within the limits of possibility.

Studies of the reflex powers of sporadic ganglia have been made upon the cardiac ganglia, the inferior mesenteric, and the submaxillary ganglion, all of which are macroscopic, besides the microscopic ganglia of the blood-vessels, etc., either known or supposed to exist. Most famous of all is the controversy of which the reflex functions of the submaxillary ganglion form the subject. This ganglion, from its size, its accessibility upon the living animal, and from the ease with which its effects upon salivary secretion can be estimated, is well adapted for use as a "test case." It is connected with the submaxillary gland by the chorda tympani, with the tongue by the lingual, and with the brain by both.

The debate was begun by Claude Bernard (*Comptes Rendus*, 1862, ii., 341), who seems to have overlooked the earlier experiments of Grainger (see above), and was taken up by Kühne (*Lehrbuch der Physiol. Chem.*, 1868, p. 3) and Vulpian (*Leçons sur l'app. vaso-moteur*, i., 311, 1875), who supported Bernard, and by Eckhard (*Zeitschrift für ration. Med.*, xxix., 74), Heidenhain (*Breslau Studien*, 1868), Bidder (*Archiv für Anat. und Physiol.*, 1867, 1), and Schiff (*Moleschott's Untersuchungen*, x., 1870, p. 423), who opposed him in the theory that the submaxillary ganglion acts as a reflex centre for salivary secretion. This celebrated discussion, so important to the student of the physiology of reflex actions, has been admirably reviewed and summed up by Dr. Michael Foster in his well-known "Text-book of Physiology," where he treats of the physiology of secretion in general, and then proceeds as follows:

"In the angle between the lingual and the chorda tympani, where the latter leaves the former to pass to the gland, lies the small submaxillary ganglion, from which branches pass to the lingual on the one hand, and to the chorda on the other; branches may also be traced toward the ducts and glands, and toward the tongue. It has been much debated whether this ganglion can act as a centre of reflex action.

"Bernard found that after he had divided the conjoined lingual and chorda at about one centimetre above the place where the chorda diverges to the gland, stimulation of the lingual at about three or four centimetres distance below the ganglion still caused a flow of saliva; this effect, however, was no longer seen when the branches passing from the ganglion to the lingual had been previously divided. He explained the result by supposing that the impulses generated by the stimulus were conveyed by afferent fibres in the lingual, along the lingual roots of the ganglion, to the ganglion, and were thence reflected by efferent fibres along the branches from the ganglion to the chorda, and so to the gland. The ganglion, in fact, acted as a reflex centre. The same apparent reflex secretion could also be induced, but less readily, by pinching the peripheral branches of the lingual near the tongue, or by dipping them into concentrated salt solution. In this case also the secretion failed to appear if the lingual roots of the ganglion were divided. Such a reflex secretion was very difficult to obtain by stimulating the mucous membrane of the tongue; but Bernard was successful when he stimulated the tongue directly with a galvanic current, or drew the tongue out and placed ether on its surface. The secretion in all these cases was accompanied by a dilatation of the blood-vessels of the gland, and the effect on the gland was indeed wholly similar to that of directly stimulating the chorda. Bernard further insisted that in these experiments no anæsthetics were to be used, and observed that

the reflex act was no longer visible when two or three days had elapsed after section of the conjoined lingual and chorda trunks. Both these facts rather militate against his view, since it seems improbable that a sporadic ganglion should be so susceptible of anæsthetics, or that degeneration and functional incapacity of the ganglion should follow upon section of the conjoined lingual and chorda, so long as the afferent and efferent connections of the ganglion with the gland and tongue were kept up.

"Eckhard, in repeating Bernard's experiments, failed to obtain any effect from dipping the endings of the lingual nerve in salt solution, or from placing ether upon the tongue, and he very naturally argued (being supported in this by Heidenhain) that the effects seen when galvanic stimulation was employed were due to an escape of the current upon the chorda fibres. Schiff did obtain reflex secretion, after section of the conjoined lingual and chorda, by direct galvanic stimulation of the tongue, and by pouring ether on the surface of that organ; but the currents necessary in the first case to produce any effect were so strong that escape must have taken place, and in the second case the secretion appeared even though the lingual was divided close under the tongue, and when, therefore, this nerve could not have been the channel for conveying impulses to the submaxillary ganglion. He further pointed out that in large dogs, at all events, certain fibres of the chorda, after running along the conjoined lingual and chorda, do not leave the lingual with the rest of the fibres going straight to the gland, but continue in the lingual close up to the tongue, then bend round, and, as recurrent fibres, run back and eventually join the nerve going to the gland. He in consequence argued that Bernard, in stimulating the lingual below the divergence of the chorda, was in reality stimulating not afferent but efferent fibres. But in such a case these recurrent fibres must pass to the chorda through the ganglion, if Bernard's result be true that the reflex effect ceases when the lingual roots of the ganglion are divided. Schiff further states that these recurrent fibres degenerate in the retrograde portion of their course when the lingual is divided near the tongue, and that no effect follows upon stimulation of the lingual if the lingual have, some five or six days previously, been divided close to the tongue, so as to cause degeneration of the recurrent fibres; provided that the stimulation be not so strong as to lead to an escape of the current to the main chorda fibres. In small dogs Schiff could not so readily demonstrate these recurrent fibres, and though he says the apparent reflex secretion is more easily obtained in large dogs, such as Bernard probably used, than in smaller ones, it is improbable that mere size should make such a difference in nervous distribution; and if an escape of current can explain the results in the one case, it can also, probably, in the other.

"Bidder's account of the nerves of the ganglion at first sight offers support to Bernard's views. In the dog he finds, passing from the ganglion direct to the tongue, medullated nerve-fibres which do not degenerate when the chorda is divided at its exit from the skull. These fibres, accordingly, would seem to take their origin in the ganglion, and to be the afferent nerves required for Bernard's views. When Bidder divided the conjoined lingual and chorda he found fibres, the chorda fibres, after about three weeks, completely degenerated; not only those forming the nerve going to the gland, but also those constituting the branches going to the ganglion, *i.e.*, the chorda roots of the ganglion. In the ganglion and in the branches going from the ganglion to the gland were seen numerous degenerated fibres in the midst of undegenerated (but non-medullated) fibres which seemed to have their origin in the ganglion itself. Thus, after complete degeneration of the true chorda fibres, there still remained intact (1) the ganglion, (2) fibres from the ganglion to the tongue, and (3) fibres from the ganglion to the gland; in fact, exactly the nervous mechanism demanded by Bernard's view. But Bidder, like Eckhard, failed to obtain a reflex secretion by pouring ether on the tongue after division of the conjoined lingual and chorda, and he found that galvanic stimulation of the nerves going from the ganglion to the tongue was of no effect, provided that errors due to escape of current on to the main chorda fibres were avoided by previously inducing, through section, degeneration of the chorda fibres, including the chorda roots of the ganglion. So that Bidder's results in the end oppose the view that the ganglion can act as a centre of reflex action. In fact, such a view must be regarded at present as not proven."

For the discussion of cardiac and other vaso-motor ganglia, etc., as reflex centres, the discussion of which belongs rather to the physiology of automatic actions, reference must be made to the original paper of Eckhard (*Beiträge zur Anat. und Physiol.*, ix.), where, also, the literature may be found *in extenso*.

Inhibition of Reflexes.—The actions of the animal body may be physiologically interrupted, postponed, or otherwise modified. Such interruption or postponement is called *inhibition*, of which the most striking example, perhaps, is the slowing or total stoppage of the automatic heart-beat by stimulation of the pneumogastric nerve. More familiar examples are the voluntary refusal to be tickled, or to sneeze, or to cough when only a strong effort of the will forbids what would otherwise happen; the frequent insensibility to pain when greater pain is being suffered; and the unsusceptibility to many stimuli, ordinarily effective (absent-mindedness or preoccupation), induced by "absorbing" pursuits of work or play. All these phenomena, and more, were well known when, in 1863, Dr. J. Setschenow, professor of physiology in St. Petersburg, published a work upon inhibition ("Physiologische Studien über die Hemmungsmechanismen für die Reflexthätigkeit," etc., Berlin, 1863) which immediately drew general attention to the subject. It had been observed already that the reaction-time of a frog is greater before than after decapitation, or, in other words, that reflex actions are more quickly performed in the absence of the brain. Setschenow states, at the beginning of his monograph, that there were at that time two possible explanations of this increase of reflex-excitability consequent upon decapitation, viz.: *first*, that since the spread of sensory (afferent) impulses must tend to weaken them according to the area over which they are extended, those which cover the smaller area should give rise to stronger reflexes. Hence, when the head is cut off, because the sensory impulses are more confined the reflex of any given impulse is more intense. Or, *second*, that the brain normally exerts an inhibitory action upon the reflex excitability of the spinal cord. This latter theory Setschenow accepts and proceeds to verify, regarding it the more worthy of support since "Ed. Weber, speaking with a certain authority (on account of his celebrated discovery of the inhibitory influence of the vagus upon the heart), had first suggested that the will, whose seat is commonly supposed to be in the brain, is in a position to exert an inhibitory influence upon the reflex functions of the spinal cord" (*loc. cit.*, p. 1). This hypothesis seemed to presuppose the existence of "*inhibitory mechanisms*," and to find these Setschenow set to work. By cutting away the hemispheres no marked effect was produced; but whenever the optic lobes or optic thalami were removed, the excitability of the cord rose; whenever they were irritated it was depressed. Setschenow concludes as follows (*loc. cit.*, p. 35):

1. The inhibitory mechanisms for the reflex activity of the spinal cord have their seat, in the frog, in the optic lobes and corpora quadrigemina, and in the medulla oblongata.
2. These mechanisms must be regarded as nerve-centres in the broadest sense.
3. The afferent nerve-fibres form one (and probably the only) way for the excitation of these inhibitory mechanisms.

In the twenty-five years which have gone by since Setschenow propounded his theory of the existence of special centres for reflex inhibition, it has found numerous adherents and opponents. The former have added little enough to the evidence upon which Setschenow's theory

is based, while the latter have made it clear that the hypothesis is probably gratuitous, the facts involved being more easily explained otherwise. To give the whole history of this debate would carry us too far into details, and for these we must refer again to Eckhard (*Beiträge zur Anat. und Physiol.*, ix.). The tendency of physiologists to-day is to look upon the inhibition of reflexes, not as a peculiar function of a special inhibitory centre or centres, but as one phase of inhibition in general, somewhat as follows: The central nervous system is a system of centres—automatic as well as reflex—closely bound together by nerve-fibres. The separate centres are to a great extent independent, but by no means entirely so, each being more or less influenced in its activity by others. Into this central system (brain and spinal cord) impulses, recognized or unrecognized by consciousness, are continually flowing from the eye, the ear, the heart, the viscera—in short, through every afferent nerve. Within the system itself impulses are started by the automatic centres and sent along its length as well as outward. Each centre, therefore, is always affected more or less by every other, and by afferent impulses arising in the peripheral sensory end-organs. To remove a quantity of these inward-bound impulses is to alter materially the conditions affecting the centres. But to remove the hemispheres of the frog is probably to remove only a very limited and (in the frog) uninfluential group of automatic centres. To take away the optic thalami, optic lobes, and medulla, however, is to remove the most important of all the incoming impulses, viz., those from the eyes, the ears, and the great pneumogastric, which of all the nerves probably modify most the more purely mechanical functions of the cord. It is not surprising, therefore, that after decapitation the cord, freed from the interference ordinarily produced by these impulses, should work, from a mechanical point of view, more perfectly, passing into an abnormally sensitive condition analogous to hyperæsthesia. Or, again, to remove the cerebral hemispheres and then stimulate the mid- and hind-brain with salt, after the manner of Setschenow, thus producing a depression of reflex activity, is plainly to intensify the impulses passing down into the cord, and to increase interference. That salt does not so readily do this when applied to the cut end of the cord after the brain has been all removed, is probably because in the former case the salt-produced impulses were added to the ordinary impulses going from the hind-brain, while now they are alone; previously they acted upon a cord already normally "depressed," while now they act upon a cord abnormally exalted. On the other hand, stimulation of one sciatic inhibits more or less perfectly the reflexes performed by the other; and yet section of one is said to depress the reflex powers of the other. The fact is, we are not yet in a position to dogmatize upon the subject of reflex inhibition, and the whole subject urgently demands further elucidation.

The Time Element in Reflex Actions.—Exner has estimated the time required for a stimulus applied to one eyelid to make the other blink. A sharp electric shock was applied, for example, to the eyelid of one eye, and the interval elapsing before the other eyelid blinked was noted, and found to be 0.0662 to 0.0578 second, being less for the stronger stimulus. If these figures be taken to represent the reaction-time, it is possible, by measuring the nerves traversed and knowing the latent period of muscular contraction, to estimate roughly the time spent in the reflex centre, which is given as 0.0555 to 0.0471 second. Without placing too much confidence upon these figures, which are probably wide of the mark owing to the numerous sources of error involved, we may still believe that much the larger portion of the time is spent in the reflex centre. Helmholtz, so long ago as 1854, came to the same conclusion, estimating the reflex-time as twelve to fourteen times greater than the rest of the reaction-time. These results form one basis of the now general belief, that the passage of the impulse through the centre is not a mere transit but an actual change, in which considerable time is consumed.

Rosenthal (*Monatsbericht d. Berlin. Acad.*, 1873, 104) asserts that the reaction-time depends on the strength of the stimulus; the stronger the stimulus the shorter the time; and that it is greater when cross-conduction is necessary than when the reflex occurs on the same side as that where the stimulus is applied. The condition of the cord is also highly influential—fatigue delaying the reflex- and increasing the reaction-time. Wundt has confirmed Rosenthal in the statement that cross-conduction is slow, but denies that the reaction-time is dependent upon the strength of the stimulus.

The Effects of Drugs, Temperature, etc., upon Reflex Actions.—The detailed treatment of the effects of different drugs upon reflexes belongs to pharmacology. It will suffice here to mention only strychnine, the effects of which are peculiar and have a direct and important bearing upon the theories of reflex action.

Magendie, even as early as 1809, found that certain vegetal matters, from which strychnine was afterward extracted by Pelletier and Caventou, produced peculiar cramps, the seat of which appeared to be the spinal cord. The same fact was more securely fixed, by the use of the alkaloid in a pure state, by Marshall Hall, in 1833, and the spinal cord has ever since been regarded as peculiarly affected by this poison, the remarkable effects of which have caused it to be widely studied.

Stannius (*Müller's Archiv*, 1837, 223) proved that when the strychnized blood does not reach the cord no spasms ensue. H. Meyer (*Zeitschrift für rat. Med.*, v., 257) found that direct application of the drug to the motor nerves is ineffective. Bernstein (*Moleschott's Untersuch.*, x., 280, 298) showed that it does not act indirectly by poisoning the blood, but directly upon the cord, by introducing it into the circulation of a frog from which the blood had been washed out by salt solution, and noticing that the spasms occurred as usual.

Meihuizen (*Pflüger's Archiv*, vii., 201) made the interesting observation that the motor nerve and the energy of the muscle in a nerve-muscle preparation is not affected. The evidence against heightened excitability in the sensory nerves is less conclusive, but points in the same direction. Apnœa prevents or does away with the spasms of strychnine-poisoning, but the explanation of the fact is not clear. Of chief interest, however, are considerations relating to the changes produced by strychnine in the cord itself; and here two theories have been proposed. The first supposes that the excitability of the cord is enormously increased, so that the smallest stimulus produces comparatively great results in the centres. The second looks upon the spasms as due to a diminished resistance in the cord, which allows the incoming impulses to roam unrestrained, as it were, up and down among the centres. At first sight the two views do not seem very unlike; but the former presupposes a change in the protoplasm of the centres themselves, making them more "explosive" and thus overcoming the normal barriers in the cord; the latter regards these barriers as broken down by the strychnine, thus allowing the normal operations of the centre to work results unusually extensive.

Concerning the effects of temperature as a stimulus, enough has already been said above, but as to the influence of temperature upon the condition of the reflex apparatus it may be remarked, in general, that there is a certain temperature at which the reflex mechanism is most active, and above and below which reactions occur less readily. It depends, therefore, upon circumstances whether a rise or fall of temperature shall give better or worse results (*cf.* Eckard, *Beiträge*, etc., p. 135, and Sedgwick, "On Variations of Reflex-excitability in the Frog, induced by Changes of Temperature," *Studies from Biol. Lab. Johns Hopkins Univ.*, ii., 385).

Laws of the Propagation of Reflexes.—One of the earliest observations of "sympathy" and reflex action was, that it is not a matter of chance or indifference what action follows a particular stimulus applied to a particular spot. The most commonplace observation shows that weak stimulation of a special spot produces a certain result in certain muscles or glands, while a more powerful stimulus affects a more extensive set of muscles, etc. The earlier observers—Volkmann, Grainger,

Valentin, and others—contented themselves with stating that movements stand in a pretty definite relation to the spot of skin stimulated. But with strong stimuli, and especially with stimulation of nerve-trunks, other phenomena occur which cannot be so simply formulated. Thus salivary secretion and movements of the pupil may follow stimulation of the sciatic, of purely sensory cutaneous nerves, or even of membranes like the dura mater.

Accordingly, Pflüger ("Die sensor. Functionen des Rückenmarks d. Wirbelth., nebst einer neuen Lehre über die Leitungsgesetze der Reflexionen," Berlin, 1853) has laid down for the human subject a series of laws calculated to define the paths of propagation of reflexes, and called by him *General Laws of Reflex Actions.*

1. *Law of the Propagation of Unilateral Reflexes.*—Whenever muscular movements follow upon the application of a stimulus to a peripheral sensory nerve of one side of the body only, and occur upon only one side, they are invariably found upon the same side as the stimulus.

2. *Law of the Bilateral Symmetry of Reflexes.*—Whenever a stimulus has affected a reflex-centre so that movements occur not only upon the same, but also on the opposite, side, it invariably happens that only those motor nerves of the opposite side are affected which correspond to the motor nerves already affected upon the same side as the stimulus, *i.e.*, the muscular movements produced are bilaterally symmetrical.

3. *Law of the Unequal Strength of Bilateral Reflexes.*—Whenever the irritation of a sensory nerve produces bilateral reflexes of unequal strength, the stronger is always upon the side to which the stimulus is applied.

4. *Law of Irradiation.*—Whenever an afferent cranial nerve evokes reflexes, the impulses travel among the centres from before backward; but whenever an afferent spinal nerve has produced reflexes through its centre in the cord, the impulses spread from behind forward.

Other laws have been given, both by Pflüger and others, but all, including some of the foregoing, have been called in question by different observers, especially by Luchsinger (*Pflüger's Archiv*, xxii., 178, etc.). The whole subject needs further investigation.

Reflex Centres.—Besides the great automatic nerve-centres, such as those of the cortex, the cerebral hemispheres, the respiratory centre, the vaso-motor centres, the cardio-inhibitory, etc., we must suppose that the brain, and especially the spinal cord, is the seat of numerous, more purely reflex, centres. But when we are asked to prepare a map showing precisely where these different centres lie, it is evident that in only a few cases can positive statements be made. The method of searching for such centres consists in tracing the afferent and efferent nerves (when this is possible), and removing portions of the cord (or brain) successively until the ordinary function is stopped or interfered with. The difficulties met with in special cases may be illustrated by referring to the search for the centre (or centres) of reflex contraction of the pupil. Flourens was the first to locate a region in the brain the destruction of which would do away with contraction of the pupil, and he placed the "centre" for this function in the corpora bigemina and quadrigemina. Longet confirmed this statement and asserted that the hemispheres, cerebellum, corpora striata, and optic thalami, could be removed without interfering with reflex contraction of the pupil. Budge located the centre on the inner side of the two anterior of the corpora quadrigemina; but Vincent (1877) asserts that it lies at the upper end of the spinal cord.

It would lead us into too many details to follow up the history of the discovery of the numerous reflex centres now known or supposed to exist. Suffice it to say, that while many are assumed, few are very definitely located. The question, which is as old as the subject itself, whether consciousness extends into these centres or into the spinal cord at all, has been much debated, and is still unsettled. There is a certain amount of evidence which seems to some to make it likely, but to others is inconclusive. If a decapitated frog be hung up and have a bit of filter paper, soaked in acid, laid upon the skin near the anus, one leg will generally be lifted and a brushing or sweeping movement will be made, as if with a *purpose* to wipe the paper off. Still more purposeful appears the movement which is made, oftentimes, if the leg ordinarily used to make the movement be gently held and prevented from moving; in which case the other leg (commonly not used for the movement) is called into requisition and makes wiping movements. This certainly seems to indicate intelligence, though intelligence of this sort is not necessarily accompanied by consciousness. It seems possible, in cases like this, to suppose merely a complicated and very perfect reflex action going on without the existence of consciousness. Moreover, the experiments of Fratscher (see p. 155), in which normal frogs sat motionless in water gradually heated from the normal to a fatal temperature, lead us to rate the normal consciousness of the intact frog as certainly not very high, at the best.

In conclusion, it must not be overlooked that the practical importance of reflexes is very great, not only to the individual, most of whose "experience" is hardly more than the resultants of repeated reflexes, but also to the practitioner of medicine, both as regards diagnosis and treatment. The digestive and other disorders due to teething in infants, the headaches resulting from decayed teeth or from defective vision, the vomiting in pregnancy, the coughing from chronic laryngeal irritation, and the like, are well understood. Less clear are the effects of over-exertion, the reactions from the stimuli—infinite in number and variety—of city life, of changes in environment, climate, food, and dress; but that these are real and produce their own peculiar reflexes cannot for a moment be doubted. The science of hygiene—if not the science of medicine—must, undoubtedly, in the future give greater heed to these multifarious stimuli, for the sake of their effects.

Therapeutics—consciously or unconsciously—has long made use of reflex actions. The use of the blister, the sinapism, and the hot iron reaches back to a very early time. Applications of heat and cold are often indispensable; and rest, *i.e.*, freedom from the usual stimuli; and sport, *i.e.*, the application of agreeable stimuli—are universally and justly recognized as the chief instruments of recreation and refreshment. Yet it is not so well recognized as it ought to be that the skin, and hence the whole nervous system, may be as truly "scourged" by sudden changes of temperature in a "trying" climate, or by clothing, as by the blister or the hot iron; and that the sensitive retina or inner ear, may be "scourged" as certainly as the skin with which it is homologous. The practical value of reflexes lies principally in the fact that in their use or disuse we have a means of reaching or resting the central nervous system, and hence of influencing more or less nearly every action or condition of the whole organism. *W. T. Sedgwick.*

REGISTRATION OF DISEASES. That knowledge which tends most directly to preserve life is the knowledge of the most common causes and conditions which lead to death. As, according to Herbert Spencer, that knowledge which tends directly to preserve life is "of most worth," so, to the human race in general, the most important questions to be settled are the causes and conditions which lead to most deaths. That the registration of deaths and their causes would be attempted by many governments was therefore to be expected.

At first sight, however, it seems strange that in this most important work so little progress has been made. One of the principal reasons seems to be, that for success in gathering such statistics there is needed the co-operation, not only of many individuals, but of many classes of people; and the importance of the subject has not been so clearly impressed upon the average person as to secure that co-operation. In this country it has been almost impossible to obtain reliable statistics of deaths or their causes, except in limited areas, such as in cities where burial permits are required for the purpose of securing such statistics. And when reliable statistics of the causes of deaths are secured, the compilation of such statistics, in ways to teach valuable general truths, is ex-

tremely difficult. Expert ability of a high order is required, and much experience in such work. The common way, however, is to entrust this work to a new man each time. In some of the States the compilation of the vital statistics is entrusted to an ordinary clerk in the State Department. Even the general government at Washington has as yet no permanent office or officer for census work, but nearly every United States Census is managed by new men, who are obliged to learn anew this most difficult of all scientific work. There is hope in the fact that people are coming to appreciate the value of statistics relating to labor, and bureaux of statistics are being demanded and created, which in time will undoubtedly do something to teach all classes of people the value of statistics, the importance of continuous systematic work for their collection, and the necessity for their compilation by skilled and experienced men.

Much has been learned from the registration of deaths; it has shown us the relative importance of the various diseases, the relative danger from each to persons of the two sexes at the different ages, and many other useful facts. When, however, we come to study the real causes of deaths, we find that we need to know a great many facts which no ordinary statistics of deaths supply. We need statistics of the meteorological and other conditions antecedent to, and coincident with, the deaths; and since, in most cases, the fatal sickness (the name of which only is given as the "cause of death") was incurred some time previous to death, the date of the death is not sufficient—we need to know the average duration of each of the diseases, in order to know how far back in time to look for the real cause of the disease. It may be thought that, as regards many of the ordinary diseases, we already know the causes, and that concerning those diseases there is no need for further research. Thus small-pox, scarlet fever, consumption, and some other diseases are known to be caused by special contagia, which are conveyed from the sick to those who become sick. But it has recently been shown by statistics[1] that the rise and fall of these diseases are apparently controlled by meteorological conditions; so it appears that, under some meteorological conditions, either there is very much less susceptibility to the disease, or the contagia are much more readily destroyed, or both; and it becomes important to gain further information which may teach us how to favor the destruction of the contagia, or to promote the insusceptibility of the people.

Registration of Sickness.—For gaining a knowledge of the causes of diseases, the registration of sickness is on some accounts more important than the registration of deaths; and in various ways efforts have been made to secure records of sickness; medical college professors have recommended to students that they record their cases; medical societies have appointed committees on prevalent diseases; the British Medical Association has inaugurated the "Collective Investigation of Disease," and in many ways the profession has shown its high appreciation of such records for the advancement of the medical sciences.

In recent times, extensive registration of disease has occurred in some of the great hospitals, in the marine hospital services, in the navies, and especially in the great armies of the world; and, in this country, the medical and surgical histories and records of the War of the Rebellion are a vast mine of valuable data, which may be made to yield knowledge of the causes and conditions of sickness from many of the most important diseases, which should go far toward teaching mankind how to avoid and prevent them. But there are difficulties in the way of inducing people to utilize these valuable records, which it may take many years to overcome. As it is not profitable for any class of persons, unless it be the insurance companies, to engage in such work, the people—that is to say national or state governments—must provide the means. The publication of the mere statistical tables is only supplying the raw material, for the utilizing of which expert ability is required, and graphic illustrations of results are essential to its proper and forcible expression; and then, on the part of those generally who are to receive it, knowledge of statistical methods, of the theory of probabilities, and how to use graphic representations, is required for its correct appreciation.

It would seem that a government can have no better function and no higher duty than the supplying of such information and knowledge, for saving the life and preserving the health of the people for whom the government exists.

The army and navy records have one advantage over other registrations of disease—namely, that of a statement of the population in which the sickness occurred—the "mean strength" of the army supplying this factor for that service. On the other hand, the registrations by civil governments give us the sickness among both sexes, at all ages, and under all ordinary conditions of living.

Outside of army and navy records, the earliest systematic effort to secure a continuous record of sickness by many observers, was that of Benjamin Ward Richardson, of London, England. Dr. Richardson says that the idea of making a registration of disease originated with him in 1852, and in 1854 he began to carry it out in his new journal of public health—the *Sanitary Review*—then a novelty in the literature of Great Britain. His registration tables were published quarterly for four years, at the end of which time observations were being taken from sixty stations, extending from St. Mary's, Scilly, in the extreme south, to Lerwick, almost in the extreme north of those islands.

Unable to continue the inquiry in consequence of the increasing expense, which multiplied with the success of the experiment, he tried, through Sir Benjamin Hall, then President of the Board of Health, to transfer the labor to the government without asking anything for himself in the matter. The suggestion was kindly received, but declined.

Dr. Richardson read a paper on this subject to the Social Science Association, at its meeting in Dublin, the meeting being presided over by the late Lord Brougham. This paper is published in the transactions of the Association for 1861, pp. 535–546.

In this country the honor of pioneer effort to have such registration of sickness done by the government, apparently belongs to the State Board of Health of Massachusetts, which, on November 1, 1874, issued a circular to "a large and select number of physicians in full general practice, in various parts of the State."[2] The plan was for each physician to send each week to Dr. F. W. Draper, in Boston, "the registrar of this new Bureau of Health correspondence," a postal card "report of diseases prevalent during the week ending Saturday, . . . 1875." From these reports a weekly bulletin was published, showing, for each of seven districts in Massachusetts, the prevalent diseases and facts of interest relative to the rise and decline of contagious diseases. At the close of the year a summary of the results was published, containing two charts showing by weeks the rise and fall of fourteen important diseases. Being for only one year, and compiled by weeks, the curves in those charts are not steady, but the fluctuations would undoubtedly disappear, in accordance with well-known laws, with more numerous occasions and a greater number of reports. These curves are very instructive, indicating as they do the strong influence which the season of year has upon sickness from each of these fourteen important diseases. In his report Dr. Draper says: "The sensitiveness of the public health to weather variations has been shown repeatedly by means of the weekly returns. A sudden change in temperature or in humidity has again and again indicated its effect upon the amount and gravity of the prevailing diseases. A single instance, which many persons in Massachusetts will recall, may be cited as an example of this. The fourth week in April, the week in which the centennial celebrations at Concord and Lexington occurred, was marked by a severe cold snap after an interval of mild weather. The sickness returns for the week represented a very decided increase of acute diseases; bronchitis, influenza, rheumatism, pneumonia, whooping-cough, measles, scarlatina, and sore throat were returned as being much more prevalent.

"It is one of the advantages of such a system of sickness-registration that it shows at any time, and without delay, the effect of the weather changes, making a far more prompt and satisfactory exhibition of the influence of such changes upon the public health than is possible with the mortality table which gathers the more distant, indirect, and partial results of the same phenomena."[3] No attempt was made, however, to bring together with these data similar exact data relative to meteorological conditions, and by this comparison to learn the causes or conditions of the rise and fall of the several diseases.

It is much to be regretted that after a single year's trial with reports of sickness, this work was discontinued by the Massachusetts Board of Health.

On July 11, 1876, the Michigan State Board of Health inaugurated a system of weekly reports of sickness by prominent physicians in active general practice in different parts of the State.[4] At first it followed somewhat closely the form and methods employed in Massachusetts, but as time and experience suggested changes, the methods and forms have been amended. One of the first and difficult changes made was from the term "prevalent" applied to disease, because there could be no scientific exactness so long as it was employed. Now, each observer reports the cases of each disease *under his own observation* in his locality; or, if he does not like to report the number of cases, he may state the "order of prevalence" of each disease, but it is confined to cases under his own observation.

Not Necessary that all Sickness shall be Recorded.—Many persons at first find difficulty in understanding how it is possible to use statistics unless the statistics include all of the phenomena to which they relate, and most physicians at first lean toward an effort to learn and report all of the sickness in their locality. To do this is entirely impracticable, and will probably remain so for generations to come; and it is not necessary, because statisticians now know how to use statistics which do not include all the cases. The theory of probabilities, the law of averages, and the disappearance of minor errors through the multiplication of instances and observations, supply the principal foundations for the work of statistics. But this is not the place to more than refer to that part of the work.

Essentials for the Registration of Sickness.—The essentials for a good registration of the sickness from the most common diseases (the most important diseases to be studied, because they cause the most sickness) are, 1, a sufficient number of reliable physicians in active general practice; 2, the distribution of these observers so as fairly to represent the area to be studied; 3, accurate reports showing for each disease its presence or absence (under the reporter's own observation), and preferably the number of cases; 4, reports, or at least records, of these facts to be made so soon after their occurrence that none of them shall be forgotten; 5, the compilation of these reports by an expert statistician who must be honest, and should also be a physician well grounded in the physical and biological sciences; 6, the union of the data thus obtained with similar data of meteorological conditions recorded by competent meteorological observers, using standard instruments, self-registering so far as practicable, and the records to be made tri-daily.

Not Essential that the Population be Known.—One hinderance to progress in the registration of diseases is the idea that no use can be made of records of sickness without a knowledge of the population in which the sickness occurs. If the number of inhabitants is not known, it is not possible to learn the proportion sick from any given disease; but that is not the most important knowledge to be gained in searching for the causes of diseases; and it is quite possible to compare one week, or other specified time, with another with reference to the sickness from a given disease, without any exact statement of the number of inhabitants. It has been found that in Michigan the distribution of sickness *locally* follows about the same law that it does *generally* throughout the State—that is to say, the "order of prevalence" of a given disease in localities "where present," is found to be practically about the same as the "per cent. of all reports received which stated the presence of the disease." It follows that, in order to learn the rise and fall of the disease over a considerable area, it is not even necessary to know the number of cases of each disease, but only to know the fact whether each observer did or did not, during the given short time, observe a case of the given disease; then a comparison of the per cent. of reports, stating the presence of the disease in the several weeks or months, will show the comparative area of prevalence of the disease in each specified period of time. It is advisable, however, that the number of cases be reported, because this gives opportunity for the study of the subject locally; and this leads to the remark that, after the *meteorological* conditions coincident with the rise and fall of each disease shall have been learned for all localities, there will remain other conditions which must be studied in order to learn why the sickness is not always associated with the same meteorological conditions in every part of the world.

Graphic Comparisons are Essential.—No ordinary person can, with reasonable effort, so master an ordinary table of mortality or sickness from a single disease by months in a single year, as to secure a correct and complete mental picture of the relations of the several months each to every other month in the year, and at the same time compare the same with a similar table relating to a condition such as temperature, which may be supposed to have relation to the sickness or mortality. If any person doubts this statement let him try it, as the writer has many times done, and afterward compare his effort with a good diagram accurately drawn to scale. As the carpenter needs his square to measure his work, and his try-square to test the angles, so it is true, and should be generally understood, that some sort of graphic representation is essential for any degree of accuracy in a statistical comparison.

Even in this discussion, diagrammatic representation is almost essential to a clear understanding of the subject.

Inasmuch as there can be no progress in utilizing the results of the registration of disease without a proper use of diagrams, every one interested in the medical sciences should be able to read easily those which are correctly constructed, and to reject those which are not correct.

The Essentials for Graphic Comparison.—The making of diagrams is very easy when one knows how; but when two or more curves are to be compared with reference to a law of causation, there are a few essential conditions which do not seem to be generally known, and which are seldom complied with by those who publish such diagrams. One of the most important principles to be observed is to insure that the fluctuations, in two or more curves to be compared, shall be measured by the same measuring rule. No one would think of comparing one piece of timber measured in feet with another measured in yards without first converting one measurement into its equivalent in the other; yet, substantially, this error is quite frequently found in published diagrams. One difficulty seems to be to firmly grasp the idea of what is to be measured and compared, and another, the idea of how to compare such dissimilar statements as degrees of temperature with per cent. of sickness.

In each such curve representing dissimilars the *variation* is to be measured and compared, and whether stated in inches or pounds, by number or by per cent., these variations may easily be brought to a "common denominator," so to speak, by planning the diagram so that the greatest variation, or extreme range, in each curve shall be the same as it is for every other curve with which it is to be compared. This is simply done by making the range of the diagram the range for each curve—the highest and lowest parts of each curve reaching the highest and lowest parts of the diagram.

This insures that the extreme range shall be the same for each of the curves. If then the variations in one curve are quantitatively related to the variations in another curve, the two curves will sustain the same relations to each other throughout their extent; otherwise they will not do so, and their lack of parallelism will be apparent.

TABLE 1.—*Exhibiting by Months, for a Period of Eight Years,* 1877–1884, *the Relation of Sickness in Michigan from Pneumonia, to the Average Atmospheric Temperature.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. Temperature. Degrees Fahr.	21.43	25.60	31.04	44.48	56.60	65.54	70.68	68.85	62.05	51.34	35.99	27.25
Av. Per Cent. of Reports stating Presence of Pneumonia	62	66	62	56	42	27	18	14	18	23	35	48

To find the scale of value of numbers applicable to a curve representing a line in a table, subtract the lowest from the highest statement to be represented; this will give the extreme range (which equals the entire distance of the diagram), and that sum may be divided into such parts that the numbers may be conveniently stated, and the entire distance occupied may be divided into parts proportionally. For instance, for a full-page (octavo) diagram, leaving room for the head and foot-notes, 6.375 inches may be occupied by the curves (see Fig. 3229).* Suppose the highest number to be represented (stating per cent., degrees, or cases) is 66, as it is in the lower line in Table 1, and the lowest number 14, the difference (52) is to be distributed over the 6.375 inches, one (per cent. or case, etc.) then equals 0.122 inch, ten equals 1.22 inch. The nearest convenient number above 14 is 20, and lines so placed that they will be opposite the value of 20, 30, 40, 50, and 60 may conveniently be used, because they are even numbers which can be easily divided. There being the value of 10 (cases, etc.) between them, these lines will be 1.22 inch apart.*

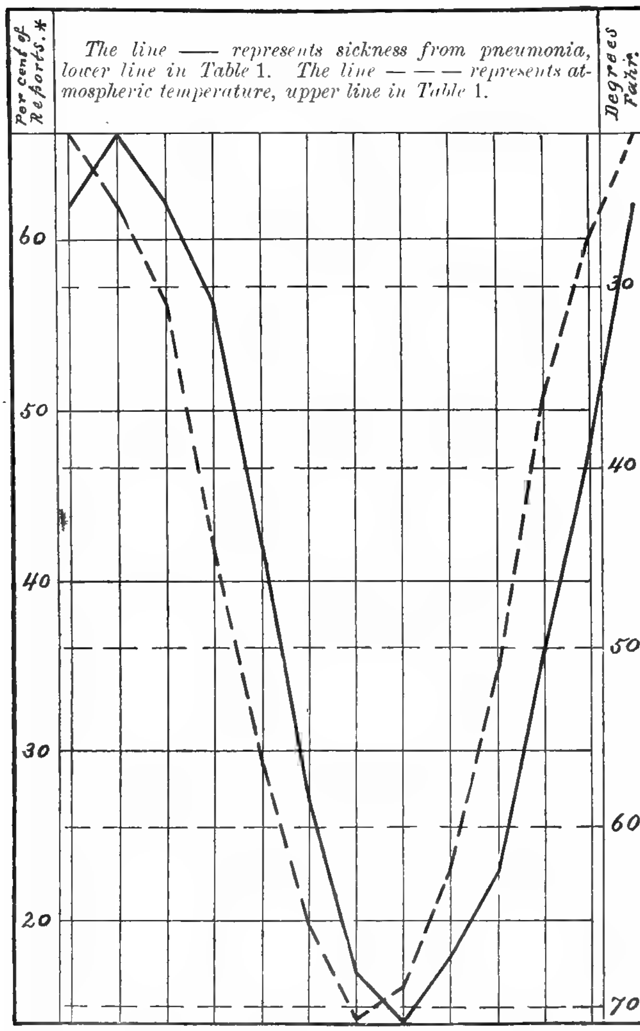

FIG. 3229.

To make a scale to use in dividing such a distance as 1.22 inch into ten equal parts,† draw along a slip of stiff paper two lines 1.22 inch apart, then place across one end of these lines a rule having ten divisions, covering a space a little more than the space between the two lines; move the rule until it crosses the space diagonally, in such a way that the nine lines on the rule will divide the space equally, and make a diagonal row of dots opposite the nine lines; move the rule along the slip a few inches and repeat the dots; then rule a short line on the end of the paper slip exactly in line with each two corresponding dots; the spaces between these lines will then all be 0.122 inch, and in this assumed case (Fig. 3230) will be the space which will represent one.‡ The ruled end of the slip of paper is then a scale which will enable a person to measure exactly the space to be allotted to any number from one to ten. But this measuring-scale is only applicable to curves representing what may be measured by the same scale and stated in precisely the same manner. It may, for instance, apply to many curves representing sickness, to many representing deaths, to many representing temperature, or even to one curve representing sickness and one representing deaths, provided both are stated by numbers of cases; but it cannot apply both to sickness and to temperature, because the values must be differently stated, and it is not usual that both values are such as to be conveniently stated together; therefore it is usually necessary to make such a scale and a set of marginal figures for each dissimilar curve in a diagram. For instance, in the diagram shown in Fig. 3229, the entire range of temperature, which, according to my rule, must equal the entire range of the diagram, amounts to 49.25 degrees, and is between 21.43° and 70.68°. In order that the variations in the temperature may be compared with the variations in the sickness, this 49.25 degrees must be proportionately distributed over the same space as that occupied by the curve of sickness. This is done, in the manner described for the sickness curve, by dividing the 6.375 inches by 49.25, when it is found that ten degrees of temperature should occupy 1.29 inch.‡

This 1.29 is subdivided by means of a rule placed diagonally, as previously described, and marginal figures are placed opposite values convenient for use—such as 30°, 40°, 50°, 60°, and 70°. When this is done

* The engraver has reduced the size of this diagram, so that instead of the curves occupying 6.375 inches vertically they occupy only 4.675 inches; but the principle of subdividing this space remains the same as described.

* The illustrative diagram (Fig. 3229) having been reduced in size, these horizontal lines are shown only .90 inch apart, instead of 1.22.

† These directions for making a scale to use in constructing or reading such a line as is the continuous one in Fig. 3229 (representing per cent. of reports showing sickness from pneumonia) were written before that diagram was reduced, and are retained because they apply to a size believed to be especially useful. For the continuous line in this diagram as reduced and here printed, the subdivision should be of .90 inch instead of 1.22, and the scale would be like that given on page 163—each subdivision representing one per cent. of reports.

‡ This was written with reference to the diagram (shown in Fig. 3229) as drawn, not as reduced in size by the engraver.

and the curves have been made, both curves have what, for lack of a better term, may be called a "common denominator," that common denominator being the total variation during the entire period of time. The curves have this in common—that the entire range of each occupies precisely the same space as does that of the other, and each curve as a whole, has the same space-value.

Referring to Fig. 3229, if the entire range (fifty-two per cent. of reports) of sickness from pneumonia is

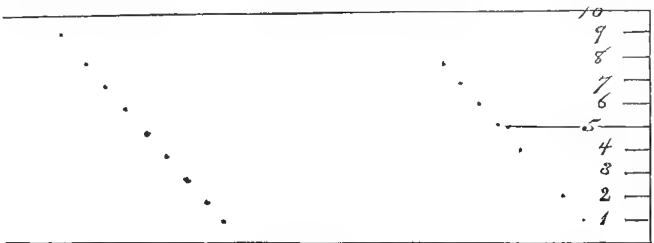

FIG. 3230.

caused by, or is quantitatively related to, the entire range (49.25°) of atmospheric temperature, then it seems reasonable to suppose that the sickness from that disease may be directly proportional to the temperature in every month of the year, in which case the curves for sickness and for temperature would be parallel throughout. The amount of parallelism in this particular case may be seen in the diagram.

It is well to have the perpendicular lines (ordinates), not the spaces between them, represent the months or other specified periods of time, then the exact crossing of the line (ordinate) by the curve is easily seen, and the degree or value of the intersection may be learned by referring to the figures in the margin; and each curve, the values for which have to be differently stated, requires its own scale and set of marginal figures, which for comparison may all be on one side of the diagram, but for distinctness and ease of reading may well be separated (as in the diagram above referred to).

When it is practicable, it seems most logical to have the degree or value of the meteorological or other condition increase from below upward, so that, as the curve representing a disease rises or falls, the fact whether the condition rises or falls will be apparent; but another fact seems to be of even greater importance to be learned, which is, just how closely, quantitatively, the two curves are related to each other, and this cannot be accurately estimated when the curves run in opposite directions; therefore the curves should accompany each other, whether or not both marginal scales read in the same direction.

Results of Registration of Sickness.—The publication of the results of the registration of sickness in England, in 1854–58, has already been mentioned.

The work in Massachusetts showed that for a single year (1875), in that State, the sickness from diarrhœa, dysentery, cholera-morbus, and cholera-infantum was greatest in August and September; from typhoid fever, in September and October; from influenza, bronchitis, and pneumonia, in the cold months. The published results contain no tables, but the charts, accurately drawn to scale, are valuable, and will undoubtedly yield much useful material to anyone who will mine it.

Some of the results of the registration of sickness in Michigan since 1876, have been published in the several annual reports of the Michigan Board of Health. In the earlier reports little more is recorded than the data, but their elaboration is commenced in ways which may suggest uses to be made of the statistics. Curves representing the sickness from each of several important diseases illustrate the report each year, and similar curves, representing the principal meteorological conditions, permit of comparison therewith. The work has now been in progress long enough to make it possible to state just what relations exist (in Michigan at least) between each disease and each important meteorological condition; and in the later reports this part of the work is commenced,[5] not, however, by presenting all of those relations, but by selecting for presentation such as seem to have causal relations to diseases of most importance. Briefly, it may be stated that the evidence seems to show quantitative (and presumably direct or indirect causal) relations between temperature of the atmosphere and all important diseases of the lungs and air-passages, including pulmonary consumption, the number of cases of these diseases rising after the temperature falls and falling after the temperature rises.[6] The rise and fall of a few diseases known to be communicable are also apparently controlled by the atmospheric temperature.[1] Intermittent fever appears to be quantitatively related to the average daily *range* of atmospheric temperature.[8] The curve for remittent fever appears to follow more or less closely the reversed curve for atmospheric ozone. The relations of atmospheric temperature to sickness from diarrhœa, dysentery, cholera infantum, and cholera morbus are graphically shown.

Such knowledge as that intestinal diseases prevail in hot weather, and that diseases of the air-passages prevail in cold weather, has been possessed by the medical profession since the time of Hippocrates, but it has had no accurately recorded, scientific basis, and no great progress can be made in eliminating the accidental, and in isolating the causal relations until records of each important meteorological and other condition shall have been passed in review, interrogated, and cross-questioned.

It would seem that a beginning has now been made in the scientific registration of diseases, by the method known as the "Collective Investigation of Disease," which, started by the British Medical Association, is spreading through this and other countries; by such governmental works as are recorded in the "Medical and Surgical History of the War of the Rebellion" in this country; by the systematic registration of vital statistics by State and other governments, and the periodical collection of such statistics by means of censuses; and finally, by the systematic and continuous registration of sickness, such as was started in England under the leadership of Dr. Benjamin Ward Richardson, was taken up for a time by the Massachusetts Board of Health and by the Provincial Board of Health of Ontario, and has been, since 1876, continuously maintained by the Michigan State Board of Health. *Henry B. Baker.*

1 Some of the Cold Weather Communicable Diseases. Trans. of Mich. State Med. Soc., 1887, pp. 56–66.
2 Report Massachusetts State Board of Health, January, 1876, p. 482.
3 Ibid., p. 491.
4 Annual Report Michigan Board of Health, 1876, pp. 26, 27. 47.
5 Typhoid Fever and Low Water in Wells. in the Report for 1884, and Causation of Pneumonia, in the Report for 1886. Mich. Bd. of Health.
6 Relations of Certain Meteorological Conditions to Diseases of the Lungs and Air-passages. Paper read before a Section of the International Medical Congress, in Washington, September. 1887.
7 Some of the Cold-weather Communicable Diseases, Trans. Mich. Med. Soc., 1887.
8 Report Mich. Board of Health, 1879, pp. 504, 505; Report for 1880, pp. 318 and 467, 468.

REICHENHALL, in Bavaria, distant four hours by rail from Munich, is a popular watering-place, visited chiefly by those suffering from obstinate catarrhal affections of the respiratory organs. The waters are also recommended in the treatment of rickets, gout, anæmia, and scrofulous adenopathies. There are about twenty saline springs at Reichenhall, the most important of which are the Edelquelle and the Carl-Theodorquelle. The waters, mixed with a strong brine, are used chiefly for bathing, though they are also drank in small quantities. The climate is mild and agreeable. The season extends from the first of May to the end of October, the last month being for those who wish to take the "grape-cure."

T. L. S.

REINERZ is a pleasantly situated Prussian health-resort. It lies at an elevation of about 1,800 feet above the sea. The air is pure and fresh, free from sudden changes

of temperature, but not very mild. The following is the analysis of the three springs used for drinking purposes, as given by Kisch in Eulenburg's "Real-Encyclopädie." One litre contains of :

	Kaltequelle.	Lauequelle.	Ulrikenquelle.
Bicarbonate of iron	0.017	0.051	0.051
Bicarbonate of manganese	0.001	0.004	0.001
Bicarbonate of sodium	0.319	0.786	0.622
Bicarbonate of calcium	0.655	1.180	1.024
Bicarbonate of magnesium	0.206	0.356	0.332
Chloride of sodium	0.006	0.015	....
Chloride of potassium	0.011	....	0.008
Sulphate of sodium	0.022	....	....
Sulphate of potassium	0.127	0.084	0.958
Silicic acid	0.036	0.065	0.016
Total	1.400	2.541	3.012

There is a large proportion of free carbonic acid gas.

There are several other springs, the waters of which are used for bathing. Besides these, therapeutic use is made largely of milk and whey from cows, goats, sheep, and asses.

Reinerz is visited chiefly by sufferers from laryngeal and bronchial catarrh, pulmonary phthisis, and chronic catarrhal diseases of the digestive organs. It is also much frequented by those run down by overwork or from other causes. The season extends from May to October. *T. L. S.*

REMEDIES, ANTAGONISM OF. Under this head will be considered only the physiological antagonism between certain drugs. Physiological antagonism between two drugs may be so extensive as to practically include almost their entire range of action, or it may be limited to one or more of their actions. We have many examples of the latter, but few indeed of the former. In fact, it is difficult to mention any two drugs the antagonism between which is complete.

Very numerous experiments have been performed on the lower animals with the view of establishing the principles which underlie the antagonistic effects between certain drugs, and also with the view of endeavoring to extend our practical knowledge in the treatment of cases of poisoning, especially of alkaloidal poisoning. Unfortunately, the results are not at all commensurate with the time and labor spent in the study of this subject. The results, however, are extremely interesting in a pharmacological sense, and have done much to extend our knowledge of therapeutics in general.

It would serve no useful purpose, even if space admitted of it, to give in detail the numerous drugs whose antagonistic effects to those of others have been carefully worked out. After all, the practical outcome of our knowledge of this subject is not so much that we can make use of it in the treatment of cases of poisoning, but rather that it saves us from prescribing drugs together that have marked antagonistic effects. It is exceedingly common to find in the one prescription drugs having directly antagonistic effects. We might instance the following, which have come directly under our own observation : The administration of digitalis and aconite in a case of loss of compensation in mitral insufficiency ; the combining together of bromide of potassium, calabar bean, and strychnine in a case diagnosed as subacute transverse spinal myelitis. No doubt, these prescriptions were put together on the "gunshot" principle. Still, if the writers had had clear and distinct views of the physiological antagonism existing between the different agents in their prescriptions, they would never have been written.

The physiological antagonism between the following drugs only will be considered :

1. Chloral and strychnine.
2. Digitalis and aconite.
3. Muscarine and atropine.
4. Atropine and pilocarpine.
5. Atropine and morphine.

1. *Chloral and Strychnine.* Both of these agents act principally on the respiratory centre and the spinal cord.

Chloral is a powerful respiratory depressor, while strychnine, on the other hand, has a powerful stimulating effect on the respiratory centre. It has been conclusively proved that after the administration of a fatal dose of chloral to one of the lower animals, life may be saved by injecting strychnine ; but I have been unable to find a single case of chloral-poisoning, in man, where there is clear evidence that life has been saved by strychnine. Numerous cases are recorded where it has been used, but in conjunction with other agents. As chloral causes death by depressing the respiratory centre, it certainly is reasonable to expect that this effect will be antagonized by an agent which has a powerfully stimulating effect on the same centre.

Chloral is, however, more of an antagonist to the effects of strychnine, than strychnine is to those of chloral. A large dose of chloral may kill before the action of strychnine is manifest. Strychnine kills by producing asphyxia, from spasmodic arrest of the respiratory muscles. It brings about greatly increased excitability of the motor centres in the spinal cord. The respiratory muscles share in the spasms with the other muscles, and death is due to the fact that they are contracted in inspiration. There are a few cases on record in which the lethal effects of strychnine in man have certainly been antagonized by chloral. In treating a case of strychnine-poisoning by chloral, the latter should be pushed until the spasms are allayed; the amount required to effect this purpose varies greatly.

Judging from the often beneficial action of choral in tetanus, we would expect a similar effect from chloral in strychnine-poisoning, which is practically an artificial tetanus. On the motor centres of the spinal cord the antagonism between chloral and strychnine is very complete, chloral being one of the most powerful motor depressants, while strychnine is the most powerful motor stimulant, that we have. Chloral being a more powerful motor depressant than strychnine is a respiratory stimulant, it naturally follows that chloral is more effective as a physiological antidote to strychnine than the latter is to chloral.

2. *Digitalis and Aconite.* There is a striking difference between the action of digitalis and that of aconite on the heart. This difference is more marked on the hearts of cold-blooded animals than on the hearts of warm-blooded animals. On applying a small quantity of aconite to the exposed heart of the frog it rapidly comes to a standstill in dilatation ; if now we apply digitalis, the distended ventricle soon recovers itself and returns to its normal condition. If more digitalis be injected, the systole becomes longer and longer and the diastole less complete, especially at the apex, which remains white and firmly contracted. This gradually extends over the whole ventricle, the heart finally coming to a standstill in firm contraction.

When either digitalis or aconite is given in such doses as to produce standstill of the heart, the pulse becomes quick, and the blood-pressure falls. "In aconite-poisoning the aortic pressure falls because the over-distended ventricle is unable to contract on its contents. Each contraction only sends a small quantity of blood from the upper portion of the ventricle. In digitalis poisoning the aortic pressure falls, because the over-contracted ventricle permits but little blood to get into it, and can, consequently, send but little forward. The result is similar in both cases, but the cause in one case is just the reverse of that in the other" (Balfour).

Owing to the slowness of the action of digitalis on the heart, even when administered hypodermically, it is doubtful whether it is able to antagonize the effects of a large dose of aconite. So far, I have been unable to find in the literature any case of aconite-poisoning treated simply by digitalis. In fact, from our present knowledge it would be very unsafe to trust to digitalis alone in such cases. The antagonism existing between these two agents is more interesting from a pharmacological than from a toxicological point of view.

3. *Muscarine and Atropine.* Muscarine, an alkaloid obtained from the fly agaric (Agaricus muscarius), has marked antagonistic effects on all the peripheral organs paralyzed by atropine. The antagonism existing between

these two agents is probably the most extensive known. Muscarine is a powerful cardiac depressant. It causes salivation, lachrymation, as well as an increase in other glandular secretions, violent contractions of the gastric and intestinal muscles, with consequent vomiting and diarrhœa, contraction of the bladder, spleen, and uterus. It produces contraction of the pupil, and spasm of the accommodation. All these effects of muscarine rapidly disappear under the influence of atropine, and, further, they do not appear at all in an animal that is completely atropinized.

Muscarine causes death by cardiac paralysis. The fatal issue can be averted by the use of atropine.

4. *Atropine and Pilocarpine.* The antagonism existing between atropine and pilocarpine is very extensive, including almost the entire actions of these two agents. Pilocarpine causes an increase in all the secretions, especially of the secretion of the sweat and saliva. The salivation is due to irritation to the terminal filaments of the chorda tympani in the glands. It is rapidly arrested by atropine, and it can be prevented entirely by giving atropine previously.

The perspiration which is due to stimulation of the sudoriparous nerves and the sweat centres can also be prevented and arrested by the use of atropine. The other secretions are stimulated by pilocarpine, and arrested by atropine.

Pilocarpine contracts the pupil and gives rise to spasm of accommodation. Atropine dilates the pupil and causes paralysis of accommodation.

Pilocarpine slows and weakens the pulse, and lowers the blood-pressure. Atropine quickens and strengthens the pulse, and raises the blood-pressure. Atropine stimulates the respiratory centre. Pilocarpine has no definite effect on it.

Cases are recorded where pilocarpine has been used successfully in cases of poisoning by atropine, but it is doubtful whether the success was really dependent or not on the treatment. The power that pilocarpine has in antagonizing the effects of atropine is much less than the power of atropine over pilocarpine. When, further, we remember that in many cases of atropine-poisoning death results from a paralysis of the respiratory centre succeeding the over-stimulation first induced, it is not to be expected that much good will result from pilocarpine.

5. *Atropine and Morphine.* The antagonistic action between atropine and morphine is, in a practical point of view, the most important that we have to deal with. Cases of poisoning by opium and its alkaloid are very numerous, and owing to the alleged powerful antagonistic effects between it and atropine, numerous cases are on record in which this alleged power has been tested.

Atropine and morphine are antagonistic in their action on the pupil, the former causing dilatation, the latter contraction. In cases of poisoning by opium we do not always find the pupils contracted.

Morphine diminishes or arrests the peristaltic movements of the intestines, while atropine has a contrary effect. The functions of the heart are not greatly influenced by morphine; atropine, however, causes a marked increase in the number of beats. The effects on the respiratory centre are antagonistic. This is *the* important antagonistic action of these two agents. Morphine causes death by paralyzing the respiratory movements, while atropine stimulates the respiratory centre. In over-doses, however, this stimulating action may be followed by a depressing one. There is a general consensus of opinion in the profession that atropine is very efficient as a physiological antidote to opium-poisoning. Numerous cases are recorded where, apparently, death from an over-dose of opium or its alkaloid has been averted by the administration of atropine. The literature of this subject is now a very extensive one. Leukartz (*Deut. Arch. für klin. Med.*, Band 40, p. 574) gives a very complete *résumé* of the cases of opium treated by atropine. In all he has collected fifty-nine cases of opium-poisoning where atropine was used. In by far the greater number of these cases other measures were employed also. Artificial respiration, strong coffee, emetics, ammonia, alcohol, etc., were the principal adjuvants to the atropine treatment. Seventeen of the fifty-nine cases died, being a mortality of 28.8 per cent.

Leukartz believes that the essential effect of the opium —the coma—is increased rather than made less by the action of atropine; and further, that atropine is powerless in combating the great danger in opium-poisoning—the paralysis of the respiratory muscles. He has collected 73 cases of opium-poisoning in which atropine was not used in the treatment, and there were only 11 deaths, a mortality of fifteen per cent. We thus have a mortality of 28.8 per cent. in the cases where atropine was employed, and a mortality of fifteen per cent. where it was not used. Leukartz from his researches comes to the following conclusions:

1. That the alleged physiological antagonism between morphine and atropine has not one single certain observation for its foundation.
2. That in the treatment of morphine-poisoning by atropine no certain improvement is to be expected.
3. That the treatment of morphine-poisoning should be carried out rationally (artificial respiration, etc.), and not by the exhibition of an alleged physiological antagonist.
4. That statistics show that the former method is much to be preferred to the latter.

Leukartz's conclusions may appear rather startling to the many who have an unbounded faith in the value of atropine in opium-poisoning. Upon a close examination of them, however, they appear to be well grounded, being founded on facts. *James Stewart.*

RENNES-LES-BAINS is a spa in the Département de l'Aude, France, lying on the Salz River, at an elevation of 1,045 feet above the sea. There are five springs, the waters of which are administered both internally and externally. The springs are known respectively as the Bain Fort, Bain Doux, Bain de la Reine, Source du Pont, and Source du Cercle. The water of the Salz River, which contains the chlorides of sodium and magnesium, and the sulphates of sodium, calcium, and magnesium, is also used for drinking mixed with the spring waters. The following is the analysis of two of the springs, according to Ossian Henry (Dechambre's "Dictionnaire Encyclopédique"). In 1,000 parts there are of:

	Bain Fort.	Bain Doux.
Calcium carbonate	0.250	0.140
Magnesium carbonate	0.070	0.030
Sodium chloride	0.071	0.181
Magnesium chloride	0.280	0.244
Potassium chloride	trace	trace
Sodium sulphate	0.090	0.120
Calcium sulphate	0.162	0.180
Ferrous carbonate	0.031	0.002
Silicic acid, organic matters, etc.	0.089	0.057
Total	1.043	0.954

The temperature of the different springs varies from 53.6° to 124° F.

A course at Rennes-les-Bains is recommended to those suffering from rheumatism, irritable nervous conditions, so-called scrofulous bone and joint affections, and enlarged glands, and also certain forms of cutaneous diseases. *T. L. S.*

REPTILES, POISONOUS. The popular mind, from the earliest period of historic time, has always turned with awe and wonder toward those mysterious gliding forms which hold in their economy the power of a swift and terrible death, a power which seems in no degree commensurate with the size of the destroyer; and this being the case, it is not to be wondered at that reptiles, particularly serpents, should have been objects of veneration and worshipped as gods, as they are even to the present day.

It would be foreign to the purpose of this paper to attempt a history of the serpent cult of all ages, its object being to call attention to certain poisonous forms, and to point out such remedial methods as may possibly mitigate the human suffering which they cause, or save the lives which they imperil.

In the subject matter which follows, no extended account of all the poisonous reptiles of the known world will be given, as this would require more space than could be allowed, but a list of our own species is furnished, with brief description of their appearance, characteristics, and the manner in which they destroy life by their bite. The physiological action of the different venoms will also be mentioned. Supplementary to this will be found brief notices of some of the more important forms of the old world.

For present convenient purposes the reptilian fauna of the United States may be considered as occupying an area bounded upon the north by the line of the Northern Boundary Survey, upon the east by the Atlantic Ocean, upon the west by the Pacific Ocean, and south by an imaginary line drawn from the southern extremity of the peninsula of California, extending eastward to the point of the Floridian peninsula.

In this vast extent of country naturalists have discovered no less than twenty-seven well-marked species of poisonous serpents, in four genera, and one poisonous lizard, the latter being the only one so far found upon the habitable globe. The first genus, *Crotalus*, contains fourteen species; the second, *Caudisona*, four species; the third, *Ancistrodon*, four species; the fourth, *Elaps*, five species; the lizard belonging to the genus *Heloderma*. The names of the serpents belonging to the genus *Crotalus* (the true rattlers) are as follows:

Crotalus lepidus Kennicott, Kennicott's Rattlesnake.
Crotalus pyrrhus Cope., Red Rattlesnake.
Crotalus Mitchelli Cope., Mitchell's Rattlesnake.
Crotalus cerastes Hallowell, Horned Rattlesnake, "Side-winder."
Crotalus tigris Kennicott, Tiger Rattlesnake.
Crotalus enyo Cope., St. Lucas Rattlesnake.
Crotalus horridus Linn., Banded Rattlesnake.
Crotalus adamanteus Beauvois, Diamond Rattlesnake.
Crotalus atrox Cope., Arizona Diamond Rattlesnake.
Crotalus scutulatus Cope., Scutulated Rattlesnake.
Crotalus lucifer Baird and Girard, California Rattlesnake.
Crotalus polystictus Cope., Spotted Rattlesnake.
Crotalus confluentus Say, Confluent Rattlesnake.
Crotalus molossus Baird and Girard, Black-tail Rattlesnake.

Belonging to the genus *Caudisona* are the following:
Caudisona rava Cope., Mexican Ground Rattlesnake.
Caudisona miliaria Linn., Southern Ground Rattlesnake.
Caudisona Edwardsi Baird and Girard, Sonora Ground Rattlesnake.
Caudisona tergemina Say, Black Rattlesnake, Prairie Rattlesnake, Massasauga.

The genus *Ancistrodon* (Moccasin and Copperheads) contains the following:
Ancistrodon piscivorus Lacépède, Water Moccasin.
Ancistrodon pugnax Lacépède, Texas Moccasin.
Ancistrodon contortrix Linn., Copperhead, Moccasin, Cottonmouth, Red-eye.
Ancistrodon atrofuscus Troost, Troost's Moccasin.

The genus *Elaps* (Vipers) contains:
Elaps fulvius Linn., Harlequin Snake, Viper.
Elaps tener Linn., Texas Harlequin Snake.
Elaps euryxanthus Kennicott, Sonora Harlequin Snake.
Elaps distans Kennicott, Florida Harlequin Snake.
Elaps tristis Baird and Girard, Tawny Harlequin Snake.

The poisonous lizard is known to science as:
Heloderma suspectum Cope., Gila Monster.

It should be stated that this list is in accordance with the "Check-list of North American Reptilia and Batrachia," Bulletin No. 24 of the National Museum, and is adopted, provisionally, by the authorities of that institution.

In view of the very general ignorance regarding the appearance of the venomous reptiles of this country, it seems desirable to give a brief account of their generic differences, as well as an account of the specific peculiarities of some of the well-known forms of the genera mentioned. *Crotalus, Caudisona*, and *Ancistrodon* belong to the family Crotalidæ, the remaining genus, *Elaps*, being a Colubrine serpent. The family characteristics of the Crotalidæ may be broadly stated as having erectable poison-fangs in front, few or no teeth in the upper jaw, a deep pit between the eye and the nostril; the general characteristics being as follows—the upper surface of the head is covered with small plates, scale-like in appearance, with a few larger ones in front; the tail terminates in a well-developed rattle; there is a deep pit between the eyes and the nostrils; the shields of the temporal and labial region are small and convex. Figs. 3231 and 3232, representing the head of *Crotalus atrox*, show very plainly the peculiarities named.

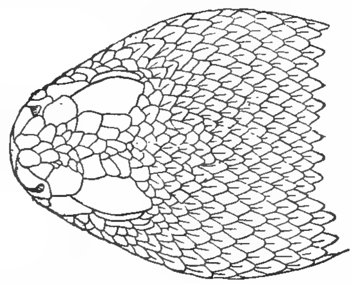

Fig. 3231.—Crotalus Atrox. View of head from above.

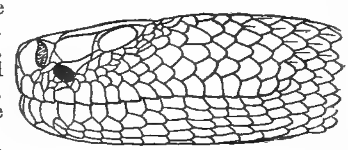

Fig. 3232.—The same, as seen in side view.

In *Caudisona* the upper surface of the head is covered with nine large plates, as is seen in the Colubrine snakes, and the tail terminates in a rattle, generally smaller than that of *Crotalus*. Figs. 3233 and 3234 represent the appearance of the head of *Caudisona tergemina*, and by comparing these figures with those of *Crotalus*, the difference in the head plates will be plainly seen. The pits anterior to the eye are also discernible.

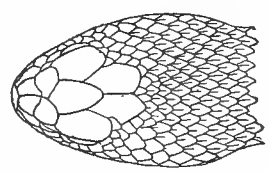

Fig. 3233.—Caudisona Tergemina. View of head from above.

In the genus *Ancistrodon*, the fangs are similar to those of *Caudisona*, and the ante-orbital pit is also present. There is no rattle on the tail, and the head is covered by either nine or eleven scales. Of the different species of this genus, one, *A. contortrix*, the Copperhead, is terrestrial, the others aquatic in their habits. Figs. 3235 and 3236 represent the head of *Ancistrodon contortrix*, the common Copperhead.

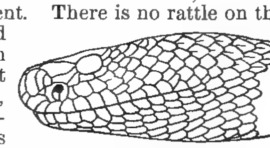

Fig. 3234.—The same, as seen in side view.

Elaps, the only venomous Colubrine serpent of North America, differs so materially from the other venomous serpents that a careful description seems necessary. The body, instead of being thick and stumpy, is slender and cylindrical, never exceeding four feet in length. The head is continuous with the body, not separated by a narrow neck as in *Crotalus*; it is subelliptical in shape, tapering forward, and is covered with plates. There is no ante-orbital pit. The mouth is not dilatable, and the upper jaw is furnished on each side with a small permanently erect fang, which is situated farther back than that of the Crotalidæ. The tail is slender and continuous with the body, and has no rattle. All the scales of the body are smooth, not keeled as in *Crotalus*. Figs. 3237 and 3238 represent the head of *Elaps fulvius*, the Harlequin Snake.

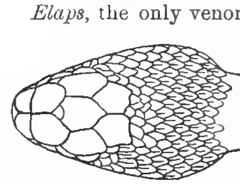

Fig. 3235.—Ancistrodon Contortrix. View of head from above.

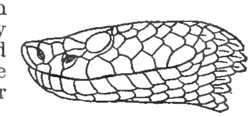

Fig. 3236.—The same, as seen in side view.

The colors of the different species of this genus are generally red for the body tint, with black, red, or yellow annulations, and their similarity to certain non-venomous snakes makes them particularly dangerous, as instances are on record of individuals having suffered in consequence of handling what were supposed to be innocuous serpents, but which really belonged to the genus *Elaps*.

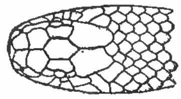

FIG. 3237.—Elaps Fulvius. View of head from above.

The genus *Heloderma* contains but one species, viz., *Heloderma suspectum*, the "Gila Monster," which may be described as a large stumpy lizard with a short tail, the whole reptile seldom exceeding eighteen inches in length. The head, sub-triangular in shape, is separated from the body by a constricted neck, and the whole of its upper surface is covered with ovoid tuberculated scales. The color is brownish-black, interspersed with yellowish spots. (See Plate XXVIII.) It is of interest because of the peculiar character of the teeth, which somewhat resemble those of poisonous serpents. Dr. Jacob Wortman, who has made a careful study of the dentition of this curious reptile, states as follows:

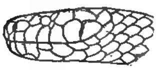

FIG. 3238.—Side view of the same.

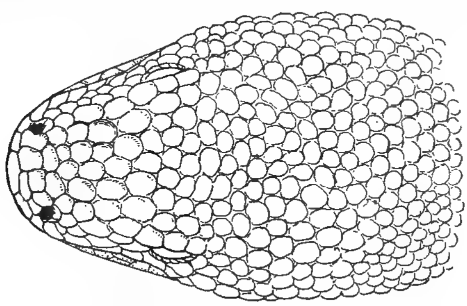

FIG. 3239.—Heloderma Suspectum, as seen from above.

"The form of the crown is that of a long, slender, sharp-pointed cone, curved inward and backward. The anterior outer surface of each tooth is marked by a well-defined groove, extending from the base to the apex. It is somewhat deeper at the base than at the summit, and is most distinct in the teeth of the lower jaw. The intervals between the bases of the teeth allow abundant room for the accommodation of poison-glands, the secretion of which is conveyed down the grooves and thus injected into the wound which the teeth inflict upon a prey."

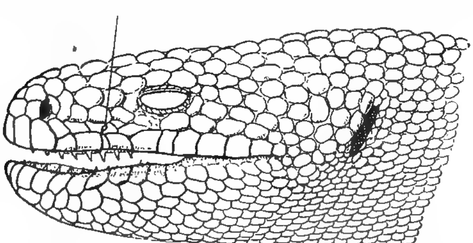

FIG. 3240.—The same; side view.

Whether true poison-glands actually do exist, has not yet been accurately determined. Figs. 3239 and 3240 will convey an excellent idea of the appearance of the head of the *Heloderma*, seen from above and in profile; the black line running vertically through the snout, having a hook at its lower end, is intended to show the lip drawn up, as under ordinary circumstances the teeth are concealed by the lips.

Having thus briefly considered the characteristics of the venomous reptiles, it may be proper to give a description of the mechanism which controls and operates the poison-fang apparatus of all our venomous serpents with the exception of *Elaps*, the account being substantially the same as was published by Dr. Elliot Coues and the writer as a result of their herpetological studies, a few years since, more modern researches having in no wise induced an alteration of the opinions then expressed.

In the production of the bite the active instruments are a pair of deciduous fangs, one on each side of the upper jaw, rooted in the maxillary bones, which bear few, if any, other teeth; but it should be mentioned as a matter of interest that, while in *Crotalus confluentus* the fangs are generally shed or pushed out of place at variable periods of time (probably in twelve months), in *Crotalus atrox*, a species common in the Sonoran region, this shedding or loss frequently fails to take place, and it is common to find, generally in the right side of the jaw of this species, two or more fangs in position. In one specimen, in possession of the National Museum, three are to be seen in position, and behind them are others well advanced in growth. The fangs vary in size, being sometimes three-fourths of an inch in length. They are somewhat conical and scythe-shaped, with an extremely fine point; the convexity looks forward, the point downward and backward. The fang is hollow for the transmission of the venom, but the construction of the tube is not as if a hole had been bored through a solid tooth. It is in effect a flat tooth, with the edges rolled over together till they meet, converting an exterior surface, first into a groove, finally into a tube. This is shown, on microscopic examination of a section of the tooth, by the arrangement of the dentine. Unlike an ordinary tooth, the fang is movable, and was formerly supposed to be hinged in its socket, since it is susceptible of erection and depression. But the tooth is firmly socketed, and the source of this movement is the maxillary bone itself, which rocks to and fro by a singular contrivance. The maxillary is a small, stout, triangular bone, movably articulated above with a smaller one, the lachrymal, which is itself hinged upon the frontal. Behind, the maxillary articulates with the palatal and pterygoid, both of which are of rod-like shape, and are acted upon by the spheno-pterygoid muscle, the contraction of which pushes them forward. This forward impulse of the palatal and pterygoid is communicated to the maxillary, against which they abut, causing the latter to rotate upon the lachrymal. In this rocking forward of the maxillary, the socket of the fang, and with it the tooth itself, rotates in such manner that the apex of the tooth describes the arc of a circle, and finally points downward instead of backward. This protrusion of the fang is not an automatic motion, consequent upon mere opening of the mouth, as formerly supposed, but a volitional act, as the reverse motion, namely, the folding back of the tooth, also is; so that, in simply feeding, the fangs are not erected. The folding back is accomplished by the ecto-pterygoid and spheno-palatine muscles, which, arising from the skull behind as a fixed point of action, in contracting draw upon the jaw-bones in such a way that the maxillary, and with it of course the fang, are retracted, when the tooth is folded back with an action comparable to the shutting of the blade of a pocket-knife. All the motions of the fangs are controlled by these two sets of antagonistic muscles, one of which prepares the fangs for action, while the other stows them away when not wanted.

The fangs, when not in use, are further protected by a contrivance for sheathing them, so that they rest like a sword in its scabbard. This is a fold of mucous membrane, the *vagina dentis*, which envelops the tooth like a hood, enwrapping its base, and slipping down over its length, partly as a consequence of its elastic texture, partly on account of its connections. Erection of the fang causes the sheath to slip off, like the finger of a glove, and gather in folds around the base of the tooth. This arrangement can readily be examined without dissection.

The poison-fluid is secreted in a gland which lies against the side of the skull, below and behind the eye, of a flattened oval shape, obtuse behind, tapering in front to a duct that runs to the base of the tooth. Without

going into the minute anatomy of the gland, it may be described as a sac, or reservoir, in the walls of which the numerous secretory follicles are imbedded; it is invested with two layers of dense, white, fibrous tissue, the outer of which gives off three strong ligaments that hold it in place. In a large snake, the entire gland may be nearly an inch long and one-fourth as wide, weighing, empty, ten or twelve grains, and having a capacity of ten or fifteen drops of fluid. There is no special reservoir for the venom, other than the central cavity of the gland. A certain dilatation of one portion of the duct, formerly supposed to be such a store-house, is due to thickening of its walls, without corresponding increase of capacity, resulting from muscular fibres which serve as a sphincter to compress the canal and prevent wasteful flow of the contents. There is further provision to this same end. When the tooth is folded back, the duct attached to its root is submitted to some strain, which pushes it against a shoulder of the maxillary bone, and tends to shut off the communication.

The injection of the venom, though to all appearance instantaneous, is a complicated process of several rapidly consecutive steps. Forcible voluntary closure of the jaws may always be, if desired, accompanied by a gush of the venom, owing to the arrangement of the muscles which effect such movement of the jaw. These are the *temporales*, one of the three of which is situated in such relation to the poison-sac that its swelling in contraction presses upon the receptacle and squeezes out the fluid. The force of ejection is seen when the serpent, striking wildly, misses its aim; under such circumstances, the stream has been seen to spirt five or six feet. A blow given in anger is always accompanied by the spirt of venom, even when the fang fails to engage, from whatever cause. But since this result does not follow upon mere closure of the mouth, it is probable that the two posterior temporals ordinarily effect this end, the more

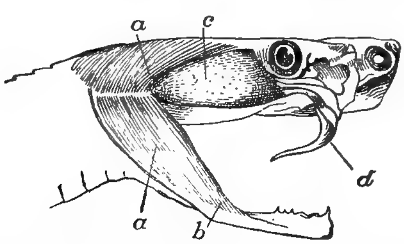

FIG. 3241.—Head of Crotalus. *a*, *a*, Anterior temporal muscle; *b*, point of insertion in the lower jaw; *c*, venom-gland; *d*, fang, partly erected.

powerful action of the anterior temporal (the one which presses upon the poison-sac) being reserved for its special purpose. There is one curious piece of mechanism to be noted here. Since the serpent snaps its jaws together in delivering a blow, the points of the fangs would penetrate the under jaw itself in case they failed to engage with the object aimed at, were there no contrivance for preventing such disaster to the snake. But there is a certain movement among the loose bones of the skull, perhaps not well made out, the result of which is to spread the points of the fangs apart in closure of the mouth, so that they clear the sides of the under jaw, instead of impinging upon it.

The complicated mechanism of the act of striking may be thus described: The snake prepares for action by throwing itself into a number of superimposed coils, upon the mass of which the neck and a few inches more lie loosely curved, the head elevated, the tail projecting and rapidly vibrating. At the approach of the intended victim, the serpent, by sudden contraction of the muscles upon the convexity of the curves, straightens out the anterior portion of the body, and thus darts forward the head. At this instant the jaws are widely separated, and the back of the head fixed firmly upon the neck. With the opening of the mouth the spheno-palatines contract, and the fangs spring into position, throwing off the sheath as they leap forward. With delivery of the blow and penetration of the fangs, the lower jaw closes forcibly, the muscle that executes this movement causing simultaneously a gush of venom through the tubular tooth into the wound. There are also some secondary actions, though all occur at the same moment. The mouth fixed at the wound drags upon it with the whole weight of the snake's body. This dragging motion is accompanied by contraction of the ecto-pterygoid and the spheno-palatine muscles, which ordinarily fold back

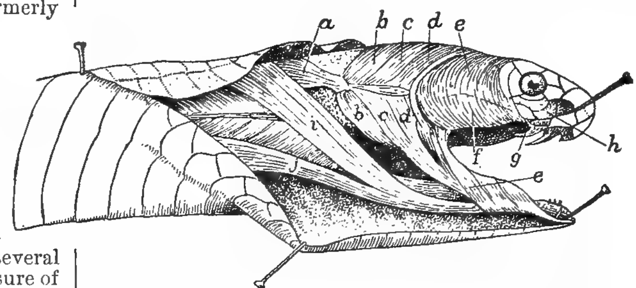

FIG. 3242.—Naja Tripudians. *a*, Is the trachelo-mastoid muscle; *b*, *b*, the digastric; *c*, *c*, the posterior temporal; *d*, *d*, the anterior temporal; *e*, *e*, the masseter; *f*, the poison-gland covered by masseter and fascia: *g*, poison-duct; *h*, maxillary bone; *i*, neuro-mandibular muscle; *j*, costo-mandibular muscle.

the tooth; but the fang being at this moment engaged in the flesh, the action of the muscles only causes it to bury itself deeper, and thus enlarge the puncture. The train of action seems to be, the reaching of the object, the blow, the penetration, the injection of the poison, and the enlargement of the wound. These actions completed, the serpent loosens its hold by opening the jaws, and disengages itself, sometimes not without difficulty, especially when the bitten part is small and the numerous small teeth have caught. The head is withdrawn, the fangs folded, the mouth closed, and the former coiled attitude of passive defence is assumed.

Fig. 3241, after Mitchell, represents the head of *Crotalus*, and shows the relation of the temporal muscles to the venom-gland, and the mode in which the pressure is exerted upon the poison-gland at the proper moment.

Fig. 3242, copied from Sir Joseph Fayrer's admirable work on the Thanatophidia of India, represents the head of *Naja tripudians*, the Cobra, the different muscles involved in the movements of the jaws and fangs being carefully delineated. By comparing this cut with Fig. 3241, it will be noticed that the fangs are fixed more anteriorly in the upper jaw than those of *Crotalus*, and the arrangement of the temporal muscles differs somewhat.

The mechanism of the jaw of *Elaps* resembles somewhat that of the Cobra, both reptiles belonging to the same class of poisonous colubrine serpents, the Elapidæ; but in *Elaps* the fang is permanently erect, the jaws be-

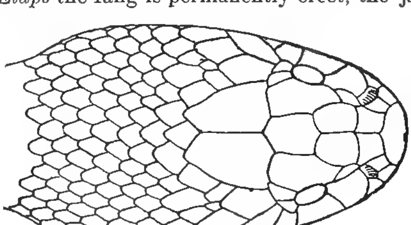

FIG. 3243.—Head of Naja Tripudians, as seen from above.

ing less dilatable than in most venomous species. This fact explains why it is that the death-dealing power of *Elaps* is more restricted than in other species.

Figs. 3243 and 3244 represent the head of *Naja tripudians* seen from above and in profile, and shows the characteristic appearance of the heads of the venomous colubrine serpents.

J. L. Ridgway del.

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DIAMOND RATTLE-SNAKE. (*CROTALUS ADAMANTEUS.*)

It is a curious fact, that notwithstanding the knowledge possessed for ages regarding the poisonous effect of serpent venom, until within the last three centuries no attempt was made to study its peculiar physiological

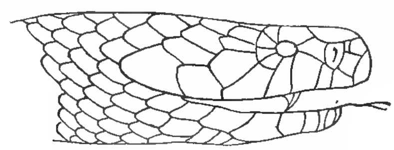

FIG. 3244.—The same, as seen in side view.

effects, the first writer on the subject being Francisco Redi, an Italian, who in 1664 published, at Florence, a paper upon the venom of the viper, entitled "Osservazione intorno alle Vipera," and this was followed, in 1767, by a work which may be considered classic, written by Felix Fontana, entitled "Richerche filosofiche sopra il veneno della Vipera," published in Lucca. In 1845, the naturalist, Prince Lucien Bonaparte, published a paper on the results of his analyses of viper venom, which was really the first scientific chemical study made. A number of other papers appeared from time to time subsequent to this, but it was not until 1860 that the most important work on serpent venom appeared. This was the "Study of the Venom of Rattlesnakes," by Dr. S. Weir Mitchell, of Philadelphia, and appeared as a volume of one hundred and seventeen quarto pages in the Smithsonian Contributions to Knowledge. In 1868, this distinguished physician supplemented his first paper by one in the *New York Medical Journal*, and in 1886, in collaboration with Dr. Edward T. Reichert, the great work entitled, "Researches upon the Venoms of Poisonous Serpents," appeared as No. 647 of the Smithsonian Contributions to Knowledge. It should not be forgotten that while our own countrymen were seeking to diffuse knowledge among mankind, the subject of serpent venom was being investigated by scientists abroad. In 1872 Sir Joseph Fayrer published a work on the venomous serpents of India; Dr. Lauder Brunton and himself published in the same year an admirable physiological study of venoms. In 1883, appeared a comparative study of the venoms of the colubrine and viperine snakes of India, by Dr. A. J. Wall; nor should the work on antidotes, by Vincent Richards, be forgotten.

The physical appearances of all serpent venom are nearly alike, varying in color from pale amber to deep yellow when fresh, although it has been stated that occasionally the *Cobra* venom is colorless; and this finds its analogy in the venom of our own *Elaps*, which has been seen on one occasion to lack color. In the desiccated condition venom appears as yellow particles, semi-transparent, and remains unchanged for long periods of time. It is equally virulent whether dry or preserved in alcohol or glycerine, Dr. Mitchell having in his possession a glycerine solution which was poisonous after twenty years' preservation. For a full description of the microscopic appearance and the changes which venom undergoes the reader is referred to the admirable study by Mitchell and Reichert already mentioned. So far as the chemistry of venom is concerned, the presence of alkaloids and ptomaïnes has long been suspected, but up to the present time they have been sought for in vain; but Mitchell and Reichert have succeeded in isolating certain principles belonging to two classes, the former termed globulins, the other peptones. To the first belong complex substances which they call *water-venom-globuline*, *copper-venom-globuline*, and *dialysis-venom-globuline*, these names indicating the chemical processes by which they have been separated. The venom peptone is found in a solution of the poison after boiling, which coagulates the albuminous principles, or it may be prepared by dialysis. In the cobra venom Drs. Mitchell and Reichert have been able to isolate two proteids which are similar in character to those found in the venoms of *Crotalus* and *Ancistrodon*, which are a globulin and peptone-like principle. From a careful series of analyses it has been found that the venom of *Crotalus adamanteus* contains 24.6 per cent. of globulins, that of *Ancistrodon* 7.8 per cent., and that of the cobra 1.75 per cent. Serpent venom has been subjected to the action of various agents with a view to determine the effects in reducing its toxic power. Dry and moist heat have little if any effect, but prolonged boiling seems to reduce the poisonous quality, owing to the fact that the peptone is converted into a coagulable albuminoid which is not destructive to life. The addition of a sufficient quantity of caustic potassa to a solution of venom, absolutely destroys the toxic power, and caustic soda appears to have the same effect. A number of other substances have been employed, but space will not admit of a further consideration of the results attained; but it may be stated as a matter of interest that a solution of the permanganate of potassa is said to be an absolute chemical antidote to serpent venom.

Much might be said of the effects of venom, but a brief notice seems all that is necessary, as the subject has been most elaborately discussed by the authors already quoted. *Crotalus* poison, if swallowed, is harmless, as it is not absorbed by the healthy mucous membrane, or because it undergoes some change in the progress of digestion which makes it harmless; but Fayrer has found that the ingestion of cobra poison by mammals does produce death. When venom is applied to serous surfaces absorption takes place most rapidly, and hæmorrhagic patches occur with surprising celerity. According to Mitchell, after the hypodermic injection of venom, the following pathological appearances may be noticed: "There appears a swelling at the point of injection, with intense violet-black discoloration of the skin which gradually extends over an area of several square inches. On making an incision into the tissues in the immediate neighborhood of the injection, they are found to be soaked with extravasated blood. This is often all that is visible if death has occurred soon, but if it has been postponed for a short time, then, in tissues distant from the place of injection, extravasations to a smaller extent are always found. Most pronounced and most frequent are the ecchymoses below serous membranes (subpleural, subperitoneal, and subpericardial); in fact the whole organism is deeply affected, the tissues being congested and presenting a much darker appearance than normal. The blood does not seem to coagulate readily within cavities or interstices of the body unless death follows almost instantaneously. In cases which live longer the blood remains constantly in a liquid state, or coagulates imperfectly, and then only after being exposed to the air, resembling in this particular the state of that fluid observed in conditions of asphyxia."

As the valuable work of Mitchell and Reichert is not generally available to the public or practitioners of medicine, it may be proper to give in their own words a summary of the conclusions arrived at, as a result of their most valuable and careful studies:

"1. Venoms bear in some respects a strong resemblance to the saliva of other vertebrates.

"2. The active principles of venom are contained in its liquid parts only. The solid constituents, such as we observed suspended in the poison, consist of epithelium cells, some minute rod-like animal organisms and micrococci, etc., which, when separated from the liquid, fresh venom by means of filtration and well washed by water, are harmless. Micrococci are constantly present in fresh venom, but have nothing to do with its virulence.

"3. Venoms may be dried and preserved indefinitely in this condition, with but very slight impairment of their toxicity. In solution in glycerine they will also probably keep for any length of time.

"4. There probably exist in all venoms representatives of two classes of proteids, *globulins* and *peptones*, which constitute their toxic elements; the former may be represented by one or more distinct principles.

"5. When venom is taken into the stomach in the intervals of digestion, enough of the poison may be absorbed to produce death, especially in the case of those venoms which contain a larger proportion of the more

dialysable peptone; but during active digestion the venom undergoes alteration, and is rendered harmless.

"6. Potassic permanganate, ferric chloride in the form of the liquor or tincture, and tincture of iodine seem to be the most active and promising of the generally available local antidotes.

"7. Venom exerts a powerful local effect upon the living tissues, and induces more rapid necrotic changes than any known organic substance. It causes œdema, swelling, attended with darkening of the parts by infiltration of incoagulable blood, breaking down of the tissues, putrefaction, and sloughing.

"8. It renders the blood incoagulable.

"9. When brought in contact with a vascular tissue of a warm-blooded animal, it produces such a change in the capillary blood-vessels that their walls are unable to resist the normal blood-pressure, thus allowing the blood-corpuscles to escape into the tissues. These lesions are, however, not analogous to those of inflammation, since in the latter process it is principally the white blood-corpuscles which emigrate from the vessels, and the blood is highly coagulable, while here the blood exudes *en masse*, and coagulates with difficulty, if at all. Free access of air (probably of oxygen) appears to lessen the virulent effects. The mesentery exposed to air, and on which the venom is merely brushed, endures the venom longer and in much larger quantities than when the poison is injected into the unopened and uninjured peritoneal cavity, or when directly thrown into the blood. There may be here, also, a question of temperature and other conditions.

"The following facts, as elicited in these investigations, seem to be sufficient to explain the mechanism of the hæmorrhages: The blood-pressure has been shown to play a most important part; a watery salt solution substituted for the blood does not extravasate, hence blood seems to be necessary; there always occur molecular changes in the blood-vessel walls from the effect of venom. That blood-pressure is an important factor has been established by the observation that the hæmorrhages, as a rule, occur first in the capillaries which are immediately next to, or nearest, the large blood-vessels. The hæmorrhages take place soonest where the force of the blood-current is first felt and cannot be sufficiently resisted, and in no case do hæmorrhages seem to originate from vessels with strong walls, like the arterioles or veins. Cutting off the circulation of a part, as, for instance, by ligation of the vessel of the mesentery, destroys the blood-pressure, and, as a consequence, the hæmorrhages are so slight as scarcely to be seen by the naked eye, though venom was freely applied. Finally, the colloid, softened, diffluent condition of the red corpuscles must inevitably facilitate extravasation. It is impossible to have seen numerous cases of venom-poisoning without noting a variety of symptoms often abrupt or unexpected. These often are due, as Dr. Mitchell long since pointed out, to accidental hæmorrhages into the brain, kidney, and heart tissues. They explain much which might otherwise seem inscrutable, and serve sometimes to give a marked individuality of symptoms to cases which survive long.

"10. Among the most remarkable effects of venom is that upon the red blood-corpuscles. These bodies undergo substantial modifications, *i.e.*, they lose their biconcave shape, become spherical and softened, and fuse together into irregular masses, acting like soft, elastic, colloid material. This jelly-like condition of the corpuscles is, no doubt, doubly important: in connection with the extravasation of the blood, and in its probable interference with the normal respiratory functions of the blood-cells.

"11. The direct action of venom upon the nervous system, save as concerns the paralysis of the respiratory centres, is of but little importance.

"12. The alterations in the pulse-rate are dependent chiefly upon two antagonistic factors which are active at the same time, the one tending to increase the rate, and the other to diminish it. The former is found in the increased activity of the accelerator centres, and the other in a direct action on the heart. When we have the action of the accelerator centres removed by isolation of the heart from any centric influence, we almost invariably find a diminution of the heart-beats. Occasionally after this operation the pulsations are increased, but this alteration is attended, as in the case of the diminution of the pulse, by feeble heart-beats, and, accordingly, is but a manifestation in another way of a depressed condition of the heart.

"13. The variations in arterial pressure are due chiefly to three causes—depression of the vaso-motor centres, depression of the heart, and irritation, and consequent constriction or blocking up, of the capillaries. It seems not improbable that all of these are consentaneously active, and it therefore follows that such alterations are dependent upon the relative degree of power exerted by any one of these factors. Our results indicate that the profound primary fall of arterial pressure is chiefly due to depression of the vaso-motor centres, and is in part cardiac, that the subsequent recovery is capillary, while the final fall is cardiac. The initial fall does not continue, because the constriction of the capillaries is, for a time at least, capable of compensating the depressed action of the central organ of circulation.

"14. The respirations are primarily increased and secondarily diminished. Here again we have two antagonistic factors at work together, one tending to increase and the other to diminish the rate. The former is an irritation of the peripheries of the vagi nerves, and the latter a depression of the respiratory centres; whether we have an increase followed by a decrease, or a decrease from the first, will depend upon the relative intensity of the action of the venom on these two parts. When the action of the venom is sufficient to profoundly depress the centres the excitation of the peripheries may prove futile.

"15. Death in venom-poisoning may occur through paralysis of the respiratory centres, paralysis of the heart, hæmorrhages in the medulla, or possibly through the inability of the profoundly altered red corpuscles to perform their functions. There can be no question, however, that the respiratory centres are the parts of the system most vulnerable to venom, and that death is commonly due to their paralysis.

"A general survey of the chief physiological actions of venoms leads us to believe that the most important effects are upon the respiratory and circulatory apparatuses, and that in the production of these results antagonistic factors are at work, so that we sometimes have observations which seem directly contradictory. When it is remembered that there are two classes of poisons in venoms, that each class possesses certain distinguishing physical, chemical, and physiological differences, although closely related, it is easy to conceive of the cause of the existence of antagonistic actions and the necessarily varying results.

"A comparative study of the actions of the *globulins* and *peptones* indicates that the *globulins* produce swelling and blackening of the parts by infiltration of incoagulable blood; they are the more potent in producing ecchymoses, in destroying the coagulability of the blood, in modifying the red corpuscles, and in the production of molecular changes in the capillary walls; their action on the accelerator centres of the heart is more notable than that of the *peptones*, hence they are more active in causing the increased pulse-rate; they exert, too, a more marked action on the vaso-motor centres in producing the primary fall of pressure, and are the greater depressants of the heart; they also act more powerfully upon the respiratory centres to paralyze them. The *peptones* are more active in the production of œdema, in the breaking down of the tissues, in the production of putrefaction and sloughing; they have little power to produce ecchymoses, to prevent coagulation, or modify the capillary walls or the blood-corpuscles; they have less tendency to accelerate the pulse; they tend to increase the blood-pressure by irritating the capillaries, and are the principal factors in exciting the peripheries of the vagi

nerves in the production of the increased respiration-rate.

"A knowledge of these peculiarities in the actions of *globulins* and *peptones*, coupled with the fact that the two classes exist in different proportions in the various species of venoms is of great importance in explaining the diverse pathological appearances in cases of poisoning in different kinds of snake-bite, and suggests immediately the cause of the frightful local changes which are seen after the bite of the Crotalidæ, but scarcely at all in cobra-poisoning. It must not, however, be supposed that the peptones or globulins, for instance, are absolutely identical physiologically in every venom, as they are probably modified physiologically as well as chemically, although we do not doubt that on the whole the type of action is carried throughout all species. Cobra venom does not produce the marked lesions of crotalus-poisoning because it is so lacking in globulins; it is weak in the production of the local swelling and blackening of the parts, of the ecchymoses, of the altered corpuscles, and of the non-coagulability of the blood; but the effects of cobra venom are closely in accord with the actions peculiar to peptones. The peptone of cobra seems to have a more decided power in producing convulsions than that of the rattlesnake.

"The fact that the active principles of venom are proteids, and closely related, chemically, to elements normally existing in the blood, renders almost hopeless the search for a chemical antidote which can prove available after the poison has reached the circulation, since it is obvious that we cannot expect to discover any substance which, when placed in the blood, will destroy the principles of venom without inducing a similar destruction of vital components in the circulating fluid. The outlook, then, for an antidote for venom which may be available after the absorption of the poison, lies clearly in the direction of a physiological antagonist, or, in other words, of a substance which will oppose the actions of venom upon the most vulnerable parts of the system. The activities of venoms are, however, manifested in such diverse ways, and so profoundly and rapidly, that it does not seem probable that we shall ever discover an agent which will be capable at the same time of acting efficiently in counteracting all the terrible energies of these poisons."

With regard to the poisonous effects produced by the venom of the *Ancistrodons* (Moccasins and Copperheads), the reader is referred to an article by the writer which appeared in the *American Journal of the Medical Sciences*, Philadelphia, April, 1884, in which special attention is called to the recurrence of symptoms of poisoning after snake-bite; this recurrence seems to be confined to cases in which individuals were bitten by the serpents of the genus named. In the *Medical News*, Philadelphia, 1887, i., p. 623, the writer, after carefully watching the two cases mentioned in the former paper during a period of nearly three years, published a short paper upon the "Recurrence of Symptoms of Poisoning after Snake-bite," in which the results of the examination of the patients and the recurrent symptoms are fully set forth.

With regard to the poisonous lizard, *Heloderma suspectum* (Gila Monster), there is a mass of conflicting evidence as to its toxic power. The Mexicans have long looked upon it as dangerous, but other perfectly harmless lizards also share in this evil reputation. Surgeon B. J. D. Irwin, U. S. A., experimented many years since, while on duty in New Mexico, with the Gila Monster, and concluded that it was harmless, and a number of persons have been bitten, within the writer's knowledge, without evil results. In fact, in New Mexico and Arizona the reptile is kept as a domestic pet, and handled with great carelessness. Opposed to the view of its non-dangerous nature are the facts that persons have undoubtedly perished from its bite, the writer having in his possession the affidavits of two respectable individuals who witnessed a death, and the experiments of Mitchell and Reichert, which conclusively show that the saliva-like fluid from the mouth of the *Heloderma*, when injected beneath the skin of an animal, produces fatal results with great rapidity.

These investigators obtained the fluid by provoking the animal to bite on a saucer edge, and after it had held on for a few moments a thin fluid like saliva was observed to issue from the lower jaw. This fluid was distinctly alkaline, differing in this respect from the venom of all serpents, which is acid. The first experiment made by these gentlemen was as follows: "About four minims were diluted with one-half cubic centimetre of water, and thrown into the breast-muscles of a large, strong pigeon at 4.23 P.M. In three minutes the pigeon was rocking on its feet and walking unsteadily. At the same time the respiration became rapid and short, and at the fifth minute feeble. At the sixth minute the bird fell in convulsions, with dilated pupils, and was dead before the end of the seventh minute. The first contrast to the effects of venom was shown when the wound made by the hypodermic needle was examined. There was not the least trace of local action, such as is so characteristic of the bites of serpents, and especially the Crotalidæ. The muscles and nerves responded perfectly to weak induced currents, and to mechanical stimuli. The heart was arrested in the fullest diastole, and was full of firm, black clots. The intestines looked congested. The spine was not examined."

Subsequent experiments with rabbits and frogs produced like results, the conclusions of the authors being, "That the poison of *Heloderma* causes no local injury. That it arrests the heart in diastole, and that the organ afterward contracts slowly—possibly in rapid rigor mortis.

"That the cardiac muscle loses its irritability to stimuli at the time it ceases to beat.

"That the other muscles and the nerves respond readily to irritants.

"That the spinal cord has its power annihilated abruptly, and refuses to respond to the most powerful electrical currents."

It should not be forgotten, however, that Dr. Sternberg and Professor Gautier have proved that human saliva may produce death in rabbits and pigeons, the latter observer considering the venomous properties due to normal ptomaines or animal alkaloids.[1]

It is by no means uncertain that in the near future it may be shown that the saliva of other reptiles possesses poisonous qualities, especially in such genera as *Siren*, *Pseudobranchus*, *Necturus*, *Amphiuma*, *Murænopsis*, and *Menopoma*, which in the Southern States are popularly supposed to be able to destroy life by their bite.

The *symptoms* produced in man by the bites of poisonous serpents possess a certain degree of similarity, their gravity depending largely upon the size of the reptile and the amount of venom injected into the wound. In case the serpent had repeatedly used its fangs and exhausted the supply of venom, dangerous symptoms would be less pronounced. Briefly, they may be stated as follows: After the puncture, at first the pain is slight in the part; this gradually increases along the line of the lymphatics, with nausea; bleeding takes place, with rapid tumefaction and discoloration in the vicinity of the wound. The pulse is feeble and fluttering, and in some cases, when an overwhelming dose of the venom has been received, the action of the heart is almost paralyzed. If remedial means are not employed there is exaggeration of all the symptoms mentioned, with incontinence of urine and involuntary passage of fæces, delirium, coma, and death, which may occur within a few hours.

These symptoms may be immediate or delayed, as in the case of the photographer bitten by a copperhead, and reported by the writer, as in this individual several days elapsed before any real suffering commenced, the entire duration of the poisonous symptoms lasting from May 30th until late in August.

Regarding the *treatment* of poisoning by serpent venom, many plans have been suggested, and hundreds of remedies employed with varying success; but to an intelligent observer of such an accident the indication would doubtless be to prevent the entrance of the poison

into the general circulation by means of a ligature or bandage, which should not be narrow, but quite broad, and applied above the bite or between it and the heart, it being, of course, understood that these remarks, so far as ligatures are concerned, apply to wounds of limbs. The bite or bites should then be laid open by crucial incision, care being taken not to injure blood-vessels, and suction should be made, either by the mouth (in case no abrasions of the mucous surface exist), or by cupping; this latter procedure may be made by means of surgical cups if available, by a small tumbler or wineglass from which the air has been exhausted by burning a small quantity of alcohol or spirits therein, or by means of an ordinary wide-mouthed bottle or can, in which boiling-hot water should be poured and quickly emptied. Alcoholic stimulants or digitalis should be given by the mouth, or hypodermatically if nausea exists, to keep up the flagging heart, and the band should be loosened for a few moments at a time in order that only a small quantity of the venom shall enter the circulation. This process should be repeated, and the pulse will indicate when the proper amount of stimulation has been reached. It is not necessary to produce drunkenness, as it is believed that in some cases, especially of children, death has resulted not from the snake venom, but from lethal doses of alcohol. The mountaineers of the West attach much virtue to the flashing of a quantity of gunpowder over the bite, this, with cataplasms of tobacco and unlimited whiskey, constituting almost their entire pharmacopœia.

Within a few years, however, the attention of those interested in the subject of serpent-bite has been called to the elaborate experiments of Dr. J. B. de Lacerda, Director of the Physiological Laboratory of the National Museum of Rio Janeiro—a study followed with most conscientious care, and one which seems to show that there exists a most potent chemical antidote to serpent venom. His researches commenced in 1872, and in 1881 he announced to the French Academy of Sciences that he had made a valuable discovery. Alluding to the inefficiency of the various so-called antidotes, he stated that he found that a solution of potassium permanganate was an absolute antidote. The venom used was from the *Bothrox*, a very well known and venomous serpent of Brazil, and it was obtained by forcing the reptile to bite upon cotton-wool. The quantity thus procured was dissolved in eight or ten grammes of distilled water, and a certain amount of the solution was injected into the leg of a dog. In a few minutes after, the same quantity of a filtered one per cent. solution of potassium permanganate was injected into the wound. Next day the animal was perfectly well, with the exception of a slight local irritation. The poison injected in other animals, without the subsequent use of the permanganate, produced grave and dangerous symptoms. The venom was also injected into a vein, and the permanganate proved equally efficacious in preventing poisonous symptoms; and in some cases, before using the antidote, the symptoms of poisoning were allowed to continue for quite a lengthy period; and out of thirty experiments all were successful with but two exceptions. It is proper to add that many of Lacerda's experiments were performed in the presence of the Emperor of Brazil, and other scientific individuals. Lacerda's experiments with the permanganate of potassa have been repeated by a number of observers with varying results, but in view of the very positive statements made by him it would appear that the permanganate should be given a trial. It should be used in the form of a one per cent. solution in water, and injected into the bites made by the teeth of the serpent.[2]

The writer, while sojourning among the Moqui Indians of Arizona, at the time of their celebrated "snake-dance," was shown the so-called antidote which they employ in case a dancer is bitten; it is a pale, dirty-green fluid, without odor, and slightly bitter taste, but its composition could not be ascertained, only two individuals in the tribe knowing how to prepare it. This preparation is used, mixed with saliva and the charcoal of piñon nuts, to smear the bodies of those Indians who are to participate in the dance, and after it is finished copious draughts of it are swallowed, which produce prompt emesis. In case one is bitten, which happens occasionally, the wound is immediately sucked, some of the antidote rubbed into the wound, and a large quantity swallowed. During the last ten years, in which period five dances have occurred, but one individual has perished from snake-bite; and this is the more surprising when the fact is made known that the salient feature of the dance consists in the dancer holding one or two rattlesnakes in the mouth. The writer saw two individuals bitten, both by harmless snakes. Unfortunately for science, no opportunity was afforded to test the permanganate solution, which had been prepared and was on hand for use should occasion offer.

After the subsidence of acute symptoms of snake-bite, the others would have to be treated according to the general indications.

Considering the number and wide distribution of venomous serpents in the United States, and in view of the fact that no absolutely reliable plan of treatment is known, it is surprising that so few individuals lose their lives from snake-bite. That the rattler is still numerous in certain portions of our country, the following statement will show: In 1876, Lieutenant Morrison, U. S. A., encountered in New Mexico a colony of *Crotalus confluentus*, of which not less than from three to five hundred were seen during the occupation of a hill as a topographical station, and of which seventy-nine were killed in less than one hour; and Professor J. A. Allen reports that during the Yellowstone Expedition of 1872, not less than two thousand were killed.

With reference to the subject of antidotes, mention may be made of a remarkable work, published by Boericke & Tafel in 1872, in which the author endeavors to prove that the galls of serpents are antidotal to their bite. In preparing the gall for use, one drop is added to ten drops of pure alcohol, and the mixture is allowed to stand for a few days, at the expiration of which period the supernatant liquid is poured off and carefully preserved in a well-corked vial. In ordinary cases of bite, five or ten drops of this tincture are added to half a tumbler of water, and a tablespoonful of the mixture is administered every five, ten, fifteen, or twenty minutes, according to the violence of the symptoms. In addition to the internal use of the gall, a cruciform incision is made over the wound, and a few drops of the preparation are dropped in. Unfortunately the value of this so-called antidote depends entirely upon the statement of its discoverer, and it is believed little credence can be attached to his published results, as Sir Joseph Fayrer, following instructions received from the author, failed utterly to neutralize the poisonous effects of the venom of *Cobra* and *Bungarus*, using the gall as directed.

The popular mind has ascribed to certain serpents properties, venomous and otherwise, which they really do not possess, and it is thought a correction of these errors may perhaps serve a useful purpose.

In some parts of the United States is found a snake belonging to the genus *Heterodon*, which inspires as much fear as the rattlesnake; in fact, the species known as *Heterodon niger* is called in Virginia the "black rattlesnake," although the want of a rattle should prove the name a misnomer. This reptile has a broad, flat head, with a somewhat constricted neck, a stout body, and a short stumpy tail, and when captured it hisses fiercely, expands the cervical ribs, and presents a very pugnacious appearance. The coloration of one species is somewhat like *Crotalus confluentus*, and, if the mouth is examined, in the upper jaw will be found fang-like teeth, which have given origin to the generic name, which means "different or dissimilar teeth." These teeth are not grooved, and are not connected with anything resembling a poison-sac. Notwithstanding its dangerous appearance it is absolutely harmless, and can scarcely be provoked to bite. Not long since, the writer had forwarded to him, by an intelligent gentleman living in the South, one of these snakes, which was declared to be one of the most poisonous known to the region; it proved to be *Hetero-*

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Plate XXVIII.

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don platyrhinus. The common names for this serpent are "puff-adder," "hog-nosed snake," "sand-viper," etc.

Next to the almost universal belief regarding *Heterodon*, is a similar opinion about the so-called water moccasin, *Tropidonotus sipedon*, and one of the old writers, in a history of Virginia, describes this serpent so that no doubt as to its identity can exist, and then gravely states that an Indian was severely bitten by one, but by the application of proper remedies finally recovered. This serpent, as is well known to naturalists, resembles the poisonous species *Ancistrodon piscivorus*, and as both are found in and about watery places, it is not surprising that their properties should have been confounded. In addition, *Tropidonotus* is a very pugnacious individual, and will bite fiercely if opportunity offers, especially if it has not been handled—in fact, even then, if roughly seized. Some time since, the writer had occasion to remove a small sebaceous tumor from below the angle of the jaw of a fine female *Tropidonotus* belonging to the National Museum, and after the operation, as it had lost a considerable amount of blood, and seemed very weak, it was placed in the pond of water in the rotunda of the Museum. Desiring to exhibit it to a friend, it was removed from the water, when it struck fiercely at the hand, throwing its upper jaw back as the venomous serpents are in the habit of doing, and at the third stroke succeeded in fixing its teeth near the base of the thumb. The pain was trifling, and had it not been for the somewhat free bleeding, an injury would hardly have been suspected; no evil consequences resulted, nor have any ever occurred, as the writer has been bitten several times by this species.

The difference in the appearance of the head between the true moccasins and the so-called water moccasin is very marked. In the former the plane surface of the head may be said to roughly resemble a triangle, the snout representing the apex, the angle of the jaws the base, the neck being narrow behind. In this species the pit between the eye and nostril is well marked. In the harmless species the head is hardly separated from the body by a constricted neck; it is rounded, and the expanse of the angles of the jaw not so well marked. It has, however, when coiled up, a very vicious appearance, and resembles greatly a venomous snake.

One of the most curious myths in regard to serpents is that of the "hoop-snake" or horn-snake, which is thus described by a recent writer: "The horned snake is the last of the poisonous serpents, and is a great curiosity. Instead of in the head, it carries its weapon in its tail, which has a horny appearance, is shaped like a cock's spur, and is from an inch to an inch and a half in length. This tail has a cavity, inclosed in which is a sharp needle-like sting, growing from the extreme point of the tail. The snake puts the end of the tail in the mouth, thus forming a hoop, and rolls forward until within striking distance, when it slips the tail from the mouth and strikes with considerable force tail foremost. The sting produces about the same effect as the sting of the adder. The horned snake is about three feet long when full grown, rather dark in color, and is oviparous. They are very scarce and seldom seen."

What is known as the horned snake in the West and Southwest is the *Farancia abacura*, of which the head and back are bluish-black above, and which has subquadrate red spots on the flanks. Its abdomen is rosy-red, with transverse or alternating bluish-black irregular spots. How or why it should have acquired the unenviable reputation it possesses, at present is unknown, for it is one of the most harmless and gentle of all snakes. That its tail ends in a horny tip is true, but the "bull-snake" of California, *Pityophis bellona*, has a similar horny tip, but neither the one nor the other ever uses it for defensive or offensive purposes. In some of the Southern States the grass lizard, *Opheosaurus ventralis*, is also called the horn snake.

Another serpent about which a curious superstition prevails is the "coach-whip snake," and lying at full length in the road it seems worthy of its popular name. To naturalists it is known as *Bascanium flagelliforme.* The anterior fourth of the body is a deep brownish-black color, which gradually becomes lighter until near the posterior part, where it is of a yellowish-gray. This coloration, in connection with a peculiar arrangement of the scales, gives it a very whip like appearance, the dark part of the body being the handle, the lighter the lash. This reptile, in the South, has long been a terror to the colored population, and many are the stories related of how drunken and belated negroes have been found dead in the road, whipped to death by the coach-whip snake. Perhaps it would not be unfair to say that it is probable that this tradition was encouraged during ante-bellum days as a wholesome corrective to the night-prowling propensities of the slaves. This serpent is very graceful, and it may be imagined that if held, provoked, or irritated, it might, in its efforts to escape, switch fiercely with its long tail and body; but as for its being able to seize a person and whip him to death, the tradition must be consigned to limbo, with others of similar nature. From the somewhat fragile nature of the ligamentous attachments of the spinal vertebræ of the reptile, it is more likely that the snake would stand a better chance of breaking its back than of inflicting serious injury.

Of all the habitable regions of the globe, the empire of India is without doubt the one in which the greatest destruction of human life takes place from the bites of venomous serpents, and it may be interesting to briefly consider some of the well-known species which contribute to the fearful result. Sir Joseph Fayrer states that the average mortality from serpent-bite is fully twenty thousand annually, and in 1869, care was taken to obtain, officially, returns of cases, which showed that out of a population of 121,000,000, in an area embracing only one-half of the peninsula of Hindostan, the deaths were 11,416, or nearly one in ten thousand. These deaths were caused, as nearly as could be ascertained, as follows: *Cobra*, 2,690; *Krait* (*Bungarus ceruleus*), 359; other snakes 839; unknown snakes, 6,922; no details, 606; total, 11,416. The British government recognizing the importance of destroying venomous snakes, paid a bounty, in 1880, for the enormous number of 212,776, and in 1881, for 254,968.

Superior in venomous properties are the *Elapidæ*, of which several genera are common in India; *Najidæ*, or snakes with hoods, or dilatable hoods, or dilatable necks; and the *Elapidæ*, without hoods. *Najidæ* contains two genera, *Naja* and *Ophiophagus*, and in *Elapidæ* are *Bungarus*, *Xenurelaps*, and *Callophis*. The characteristics of the family are a cylindrical body, a rather short and tapering tail, and a lateral nostril. The poison-fang has a mark in its convexity indicating the groove, differing in this respect from the poisonous water-snakes, *Hydrophidæ*, in which it is quite open. At the head of the list should be placed the *Cobra*, or *Cobra di capello*, *Naja tripudians*, of which there are a number of well-recognized varieties, all of them possessing most deadly properties. The largest *Cobra* seen by Fayrer had attained a length of five feet eight inches, and measured six and one-fourth inches in circumference, and a fowl bitten by it perished in one minute. The color of the *Cobra* varies from dark olive or black, to pale chocolate or yellow, and the markings on the hood vary greatly in the different varieties. All of them possess the hood, and never bite without expanding it, and, unlike the rattlesnake, the body is not coiled, the lower two-thirds remaining upon the ground while the anterior third is raised, the head oscillating from side to side with wary caution in preparing to attack. They are good climbers and take readily to water, although essentially terrestrial in habits. *Ophiophagus elaps* is the only representation of its genus, and is probably even more formidable than the *Cobra*, as it attains a length of from twelve to fourteen feet. It has no hood and is exceedingly aggressive. The coloration varies greatly, but the general tint may be described as olive-green above, the scales edged with black, the trunk having on it numerous alternate black and white bands converging toward the head. To the Bengalese it is known

as the "shell breaker," and its habits are largely arboreal, although it takes to the water. Dr. Carter relates the following anecdote regarding its fierceness. "An intelligent Burman told me that a friend of his one day stumbled upon a nest of these serpents and immediately retreated, but the old female gave chase. The man fled with all speed over hill and dale, dingle and glade, and terror seemed to add wings to his flight, till reaching a small river he plunged in, hoping he had then escaped his fiery enemy; but lo! on reaching the opposite bank up reared the furious *Hamadryad*, its dilated eyes glistening with rage, ready to bury its fangs in his trembling body. In utter despair he bethought himself of his turban, and in a moment dashed it upon the serpent, which darted upon it like lightning, and for some moments wreaked its vengeance in furious bites; after which it returned quietly to its former haunts." This serpent, as its name implies, devours other snakes, but it doubtless also feeds upon birds and small animals.

The genus *Bungarus* contains two Indian species, *B. fasciatus* and *B. cæruleus*, known to the natives as *Kraits*, and these serpents, next to the *Cobra*, are probably the most destructive to human life in India. The coloration of *Bungarus* is uniform blackish-brown, the head being white in young individuals, although as in the other serpents there is some variation of tint. In *B. fasciatus* the triangular shape of the body and sharp dorsal ridge are especially noticeable. *Xenurelaps bungaroides*, the only known representative of its genus, resembles greatly the *Bungarus;* but little is known as to its habits.

The genus *Callophis* contains a number of species, but from their small size and diminutive fangs they are probably not so dangerous to human life as the other venomous serpents.

Belonging to the viperine serpents is the terribly venomous *Daboia russelli*, which is of a light chocolate color, with black white-edged rings, and which also shows many variations of tints. It is most justly dreaded, for with its long, movable fangs it produces deep mortal wounds. It is terrestrial in its habits, and lives upon small animals. Dr. Imlach states that it is not uncommon to find two fangs on both sides of the upper jaw.

There are a number of other genera of poisonous serpents in India, such as *Echis, Trimeresurus, Peltopelor, Halys*, and *Hypnale*, which resemble the North American *Crotalidæ* in having the ante-orbital pit, and are without rattles; but space will not admit of a consideration of their peculiarities.

The most interesting of all venomous serpents are probably the sea-snakes, which inhabit the estuaries and tidal streams, and are known to naturalists as the *Hydrophidæ*. They have a wide geographical distribution, being found in the Indian and Pacific Oceans from Madagascar to the Isthmus of Panama; Günther says they are most numerous in the Eastern Archipelago and in the seas between Southern China and North Australia. The sea-snakes vary greatly in form, some of them attaining a length of five feet; the body is elongated, and in some instances is short and thick, while in others it is very thick toward the tail and much attenuated near the neck, the head being minute in proportion to the size of the individual. The posterior part of the body and the tail are flattened and compressed vertically, like the tail of a fish, and with it they swim with extreme grace. The fangs and jaws of the sea snakes are generally smaller than those of land-serpents, the venomous teeth having open grooves. That they are venomous is without doubt, as several instances are on record of persons losing their lives, and Fayrer found by actual experiment the dangerous nature of their venom. Belonging to this family are seven genera. *Platurus, Aipysurus, Disteira, Acalyptus, Hydrophis, Enhydrina*, and *Pelamis*, and of these the latter only is known to be found occasionally near the Isthmus of Panama. *Platurus* contains two species; *Hydrophis*, twenty-seven; *Enhydrina*, two; and *Pelamis*, one. The coloration of the sea-snakes varies greatly, one of the most beautiful being *Pelamis bicolor*, the back of which is slaty black, the belly orange. Another very beautiful species is *Hydrophis nigrocincta*, in which the ground color is fawn, the entire body being partly surrounded with lake-brown circles.

In the experiments reported by Fayrer as having been made by Dr. W. P. Stewart, at Pooree, British India, the virulence of the venom of the sea-snakes is abundantly proved.

Fayrer's experiments, which were made upon different sorts of animals, using different kinds of serpent-venom, led him to the following conclusions.

Snake-poison acts with most vigor on the warm-blooded animals; birds succumb very rapidly; a vigorous snake can destroy a fowl in a few seconds. The power of resistance is generally in relation to the size of the animal, though not altogether so; cats, for example, resist the influence of the poison almost as long as dogs three or four times their size. Cold-blooded animals also succumb to the poison, but less rapidly. Fish, non-venomous snakes, mollusca, all die. After death from cobra-poison the blood coagulates, but generally remains fluid after the bite of a viperine serpent.

With regard to treatment of snake-bites, Fayrer tried every reputed antidote and every plan of treatment, but without success, although he believes that ligature, excision, and general treatment seem to afford some chance. Much, however, needs still to be done in the way of experimentation.[3]

It would be foreign to the purpose of this article to give an account of all the venomous serpents of the world, but the names of a few may be added to swell the already formidable list.

In Europe the most dreaded serpent is the *Pelias berus*, common viper; in Australia the *Hoplocephalus curtus*, tiger-snake; in Africa the different species of *Clotho, Megæra*, etc.; in South America the different species of *Craspedocephalus*, the *Jaracacas* and *Fer de lance;* while in Costa Rica particularly is found a genus of venomous serpents known as *Teleuraspis*, which are allied to the *Crotalidæ*, but have no rattles. These snakes are arboreal in habit, and present no less than five color variations, the most beautiful of all being of a golden-yellow color. A peculiarity of the genus is the presence of a series of scales above the eye resembling small horns. It is said that these serpents, which are very venomous, lie at full length along the branches of trees, striking at the faces of passers-by. In Mexico a large *Elaps* and the various *Crotalidæ* are most justly feared.

The illustrations which accompany this article have been drawn with great care by Mr. John Ridgway, of the Bureau of Ethnology, United States National Museum, from certain cuts already shown in the various works on Serpents; in other instances they have been copied from life, and leave nothing to be desired in the way of drawings. The large colored plate of *Crotalus adamanteus* has been drawn from a fine specimen owned by the National Museum, and that of *Heloderma suspectum* is by Mr. A. Zeno Schindler, copied from a living reptile in the same institution. Acknowledgment is also made to the published works of many authors, the most prominent being those by Mitchell and Reichert, Fletcher, Cope, Garman, Fayrer, Halford, and others.

[1] With regard to the very poisonous qualities of the Heloderma saliva recent experiments by the writer would seem to indicate an extremely feeble toxic effect, at least so far as rabbits and fowls are concerned.

[2] It is to be regretted that a repetition of Lacerda's experiments with the permanganate by the writer has not given the results claimed by the distinguished Brazilian.

[3] A series of experiments are now being tried to verify what appears to be decided antidotal effects of Jaborandi to Crotalus venom, the writer having succeeded in saving rabbits which had received fourfold lethal doses of the poison. It has no antidotal effect, however, upon fowls.

Henry Créry Yarrow.

RESECTION OF JOINTS.—In the strictest sense, the terms resection and excision as applied to joints are not synonymous. The former involves the primary idea of the removal of a section of a bone, especially of its shaft; the latter refers more particularly to the removal of the joint as such. As a joint is excised by the resection of the ends of the bones that compose it, the terms in

practice become synonyms, and are so found in standard works. It may be noticed that in French and German works the term resection is commonly employed; in English and American writings excision is more in use. In this article they will be used as practically synonymous. The term exsection is also used in the same sense.

Resections have been divided into *complete* and *partial*, the former meaning operations in which all the component bony surfaces are removed, the latter operations in which the articulating surface of one bone, or of more, in some complex joints, is left. Here again the nomenclature is not always strictly adhered to—as applied to the shoulder or hip for instance,—and writers seem to be not at all agreed as to what constitutes a complete excision of some joints, notably the wrist.

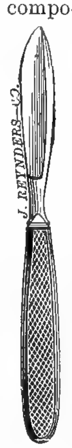


FIG. 3245.

The term osteoplastic is applied to resection in the performance of which a bone or bony prominence (*e.g.*, the trochanter major, the olecranon, or the patella) is divided and the parts temporarily separated, in order to expose the diseased tissues, and subsequently replaced more or less perfectly *in situ*. The same term has been applied to operations analogous to those of plastic surgery in which the sawn surfaces of bones not normally in apposition have been brought together after the removal of the intervening parts; for example, Mikulicz's osteoplastic resection of the tarsus. It is not easy to see why such operations are more osteoplastic than many others in which anchylosis is sought for, ordinary resection of the knee, for instance.

It is unnecessary to enter upon the history of resections. Scattered through surgical literature are allusions to operations, made to meet emergencies, more or less resembling modern resections. But it is little more than a century since Henry Park (1783) first formally proposed the removal of the elbow and knee joints for the cure of disease, and Moreau soon after (1786) made the first complete operation and became the advocate of it as a definite surgical procedure. Nevertheless resections gained footing with such slowness that their real history belongs to the present century, and chiefly to its second half. Excision of the shoulder, by reason of the ease of the operation and the disabling mutilation it promised to prevent, became an accepted operation earlier than the removal of other joints. The labors of Syme, beginning about 1831, made the profession acquainted with the value of elbow-resection, and the authority and teaching of Ferguson in the decade following 1845 fairly put excisions of the hip, knee, and wrist among recognized procedures, however much surgeons differed as to their real value and applicability. Continental surgeons were also engaged in working out the problems of excision, but the influence of the two British surgeons named was especially powerful.

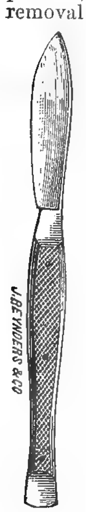


FIG. 3246.

Resection was primarily an attempt to escape the disaster of an amputation. Hodges,[1] in his classical monograph, says: "It is only as a substitute for amputation in traumatic lesions, and in certain organic ones, that the proposition of excising joints has been entertained, excepting in those comparatively few cases in which the operation has been undertaken for the cure of deformities or in disease of the hip-joint where it is the sole operative alternative." It was in the spirit of conservatism that Ferguson in particular urged the resort to excision. To surgeons of the present day, at least in America—excision seems a radical procedure, and they have difficulty in appreciating the condition of affairs existing thirty or forty years ago. To-day, in a case of joint disease, we choose between resection and a highly perfected plan of treatment by joint-rest and expectancy in its best sense. Then the choice was between amputation, on the one hand, and probable death, or, at least, painful and disabling disease of indefinite duration, on the other. Under such circumstances a procedure which gave better chances as to life or function was a boon, and truly conservative, even if hidden under the guise of a somewhat complicated surgical operation.

To establish the true value of resections, it is necessary to determine, first, whether they are really conservative of life as compared with either amputation or expectant

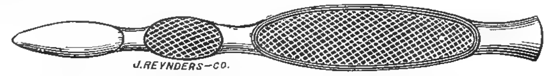


FIG. 3247.—Sands' Periosteotome.

treatment, and, second, whether the limb saved is really a useful member and worth the suffering and the risk. With regard to some joints these points are entirely settled; as to others, there is not yet entire unanimity of opinion. Before the introduction of aseptic surgery, the question of vital conservatism was kept open by the considerable death-rate of excisions, dependent upon prolonged suppuration and its results. Since the change in surgical


FIG. 3248.—Sayre's "Oyster Knife."

methods has reduced the operation-death-rate in civil practice of both amputations and resections to a much lower figure, the question is no longer very important, except as to the results of operative interference of any kind when compared with those of purely conservative treatment. And it should be noted that asepsis has had its influence not on the greater operations alone, but upon the minor substitutes for them, such as incision and

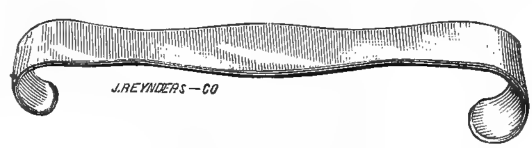


FIG. 3249.—Parker's Retractor.

drainage, as well as upon conservatism pure and simple. The vital prognosis being a matter of less urgent consideration, the functional prognosis has taken a proportionally more prominent place.

There is no doubt that the different estimates at present set upon resection in different countries depend upon the value of its alternatives. In America and in Great Britain, certainly, even before the prevalence of aseptic surgery, resections were almost confined to those classes whose circumstances did not allow them the best kind of conservative treatment. The same, we think, is at least measurably true of other countries, and wherever joint-diseases are very common among the very poor, then operative procedures are not only much more frequently resorted to but are also much more necessary than they would be under more fortunate circumstances.

The *instruments* necessary for resections of joints are essentially the same as those for other operations on bone.

For the division of the soft parts and the denudation of the bone are required knives, periosteotomes, and retractors. The knife should be strong and broad-bladed, the handle roughened to assure firmness of grasp (Fig. 3245). It is sometimes convenient to have the handle terminate in a periosteotome (Fig. 3246), but in operative surgery, as in other mechanical arts, combination-tools are usually annoyances, and perform no one office really well.

FIG. 3250.

Periosteotomes are of very various patterns. The essentials of a good one are that it shall be strong enough for its work, its handle sufficiently large and rough, its edge sharp enough to avoid any contusion of tissues, and

to easily and completely remove the periosteum, while it shall not be so sharp as that of a knife or any instrument intended for cutting the soft parts. Figs. 3247 and 3248 represent two patterns much used in

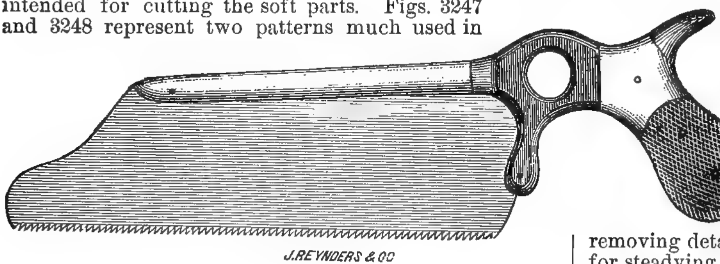


FIG. 3251.

this country. The latter is Sayre's "oyster-knife," and when the edge has just the right degree of sharpness, it is a very efficient instrument. Ollier's periosteotomes resemble dull chisels and flattened gouges.

Retractors may be of thin German silver (Fig. 3249) or

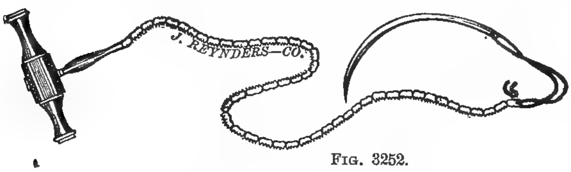


FIG. 3252.

of steel (Fig. 3250), the latter being made of various patterns with sharp or blunt points. Those which give the most certain control of, while doing the least injury to, the parts, are the best.

For the removal of the bony parts various forms of saws and of cutting and holding forceps are required.

FIG. 3253.

The ordinary amputating saw (Fig. 3251) is quite sufficient for most operations on the larger joints. Occasionally other forms of saw are convenient. The chain-saw (Fig. 3252) is useful where it is desired to sever the bone without raising it from its bed in the tissues; as, for instance, the neck of the femur in excision of the hip. In

FIG. 3254.

some situations the small saw with movable back (Fig. 3253) is very convenient, as is the key-hole saw (Fig. 3254). Butcher's saw, with its thin rotating blade, or the similar instrument of Szymanowski (Fig. 3255) is rarely demanded, although useful where cuts of curved or varied directions are to be made. For the division of small

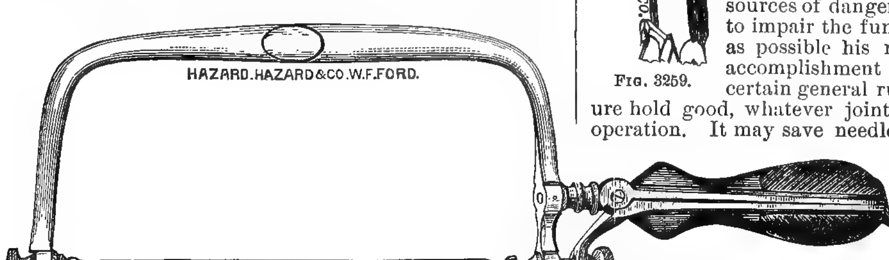


FIG. 3255.

bones the cutting forceps, either straight (Fig. 3256) or bent (Fig. 3257), are often handier than any saw. Cutting forceps of various shapes (Figs. 3258, 3259), and the gnawing, or rongeur, forceps (Fig. 3260) are necessary for the removal of the edges of bone and of diseased parts not otherwise accessible. For this last object gouges, to be used by hand (Fig. 3261) or driven by the mallet (Figs. 3262, 3263, and 3264), are very useful. So, too, are bone-scoops (Figs. 3265 and 3266), and occasionally the chisel (Fig. 3267). For removing detached pieces of bone, and for steadying the parts, the holding forceps (Figs. 3268 and 3269) are needed. For the last-named purpose the "lion-jaw" forceps of Ferguson (Fig. 3270), or that of Farabeuf, are preferable.

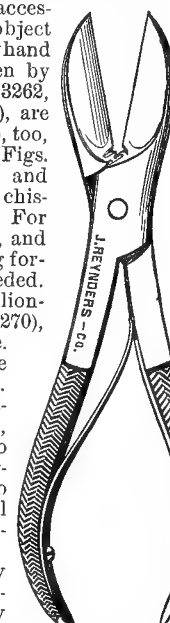
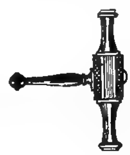


FIG. 3256.

When the bony parts are to be fastened by gut or wire, drills (Fig. 3271) are necessary to the introduction of the suture, and if nails are to be used for the purpose, it is better to make with the drill a preliminary channel to guide them.



The elaborately planned and carefully executed resections of to-day could scarcely have existed previous to the use of anæsthetics; the facility and certainty of their performance have been immensely increased by the Esmarch bandage; and their danger reduced to a minimum by aseptic methods. It is assumed in what follows that, wherever necessary, these adjuvants to success will be employed. Whatever aseptic precautions and dressing are used, they should be those in which the operator has faith and with the details of which he is familiar. In the hospitals of this city (New York), in bone-surgery, the favorite method seems to be the bichloride of mercury for douching; iodoform and iodoform gauze for the wound-application, and iodoform or bichloride gauze for the envelopes. It is convenient and efficient.

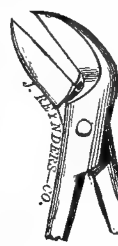


FIG. 3257.

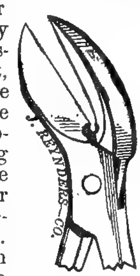


FIG. 3258.

The general law of surgery, to do the least possible damage to the parts consistent with the full accomplishment of the end sought, emphatically applies to joint-resections. To extirpate the disease or to remove the sources of danger is the surgeon's first care, to impair the functions of the part as little as possible his next. To the accomplishment of these ends certain general rules of procedure hold good, whatever joint is the seat of operation. It may save needless repetitions if some of these are considered in this place.

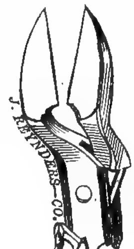


FIG. 3259.

Incisions.—All incisions should be so made as to avoid important vessels and nerves, and wherever possible they should avoid muscles and tendons. The latter requirement can usually be accomplished by using the intermuscular spaces as avenues of approach to the bone. When a muscle must be cut, let the incision

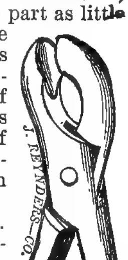


FIG. 3260.

as far as possible follow the direction of the fibres of that muscle, avoiding its nerve. The situation of an incision is often determined by pre-existing wounds or sinuses. Simple incisions are preferable, but should not be adhered to to the embarrassment of the operator ; broken incisions

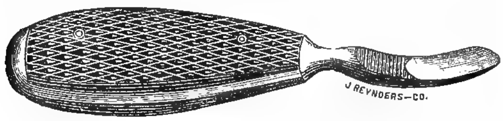


FIG. 3261.

or transverse cuts may sometimes be demanded for convenience. All incisions should be ample, without being excessive ; if the previous rules are observed a long incision is of no harm. Two or more independent incisions are often convenient. It is often possible to make an incision, in a sense exploratory, which will be sufficient for arthrotomy, resection, or amputation, as the condition of the explored parts may demand. Usually the same incision that traverses the overlying parts divides the capsule also. The same rule as regards extent of incision, *i.e.*, ample but not excessive, applies to the capsule as to other soft parts, if it is intended to preserve the mobility of the joint.

FIG. 3262.

Tendons should be preserved in their entirety, and if possible remain undisturbed in their sheaths, and their insertions carefully dissected away from the bone if the latter is to be removed. Or, what in many places is preferable, a small piece of bone may be chipped or pried off attached to the tendon. If by accident or through necessity a tendon is divided, suture of it with catgut is desirable; but the fact that suture of tendons is often successful should not be made a ground for unnecessary injury to them. The occasional surprising restoration of a destroyed or lacerated tendon, and the success following the interposition of a leash of catgut or a piece of animal's tendon in the interval when the divided ends could not be approximated, should encourage the surgeon to every endeavor to preserve the functions of tendons. The management of the *soft parts* during the operation deserves a word. One often sees during an excision the operator or his assistants, intent upon denuding and removing the bone, maltreat the soft parts, forgetful of the processes of repair. The tissues are overstrained to make room which could have been more easily obtained by a more generous incision ; they are torn with sharp retractors or bruised with blunt ones, sometimes lacerated by the violence with which the bone to be sawn is thrust out, and lastly they are teased and nicked by careless sawing. Such errors only need to be pointed out to be corrected.

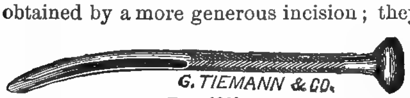


FIG. 3263.

How the *periosteum* shall be dealt with is still an open question among surgeons. Many operators ignore it, or

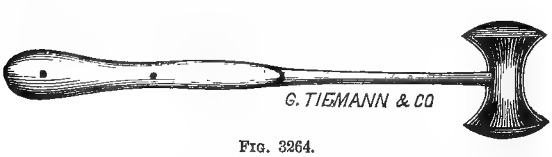


FIG. 3264.

pay little attention to it. The bone having been reached in an operation, it is neatly cleared of the soft tissues by sharp or blunt dissection, with no especial care to save the periosteum. The advocates of the *sub-periosteal method*, on the other hand, insist upon the careful preservation of this membrane. Against the method it has been urged that it is difficult and tedious in execution, and that it has not given better results than the other plans (which Ollier styles the *parosteal*). Further, it has been accused of favoring anchylosis of the excised joint. It is admittedly a slow method, but excisions are rarely undertaken upon patients whose condition demands speed in operation.

FIG. 3265.

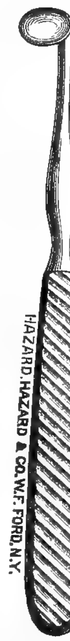


FIG. 3266. — Hebra's Scoop.

Ollier is perhaps the most ardent advocate of the preservation of the periosteum intact, although he has the support of other eminent surgeons, prominent among whom are Langenbeck in Germany, and Sayre in America. The former claims[2] for his method that, by going directly to and through the capsule, and then carefully turning back the periosteum with all its overlying tissues undisturbed, the traumatism is reduced to a minimum ; that the envelope left after the removal of the bones, which he styles the periosteo-capsular sheath, is at once a protection to the soft parts and a support to the bones, retaining the latter in more normal relations during the reparative process ; and that the reparative process is itself much more efficient, and that the functional results are much better than can be obtained by the other method. He further maintains that the method, if time is allowed, is not difficult. Making all allowance for enthusiasm, it would seem that these claims are mainly sound. The chief point, namely, that better functional results are obtained, is the very one that is difficult of proof. Excellent results have been obtained

FIG. 3267.

by both methods. One man's results can with difficulty be compared with another's ; the conditions under which they are obtained may also vary exceedingly. It is, however, fair to say, in estimating the value of the sub-

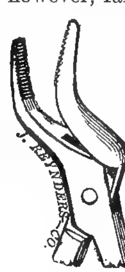


FIG. 3268.

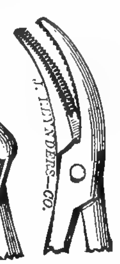


FIG. 3269.

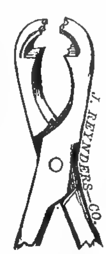


FIG. 3270.

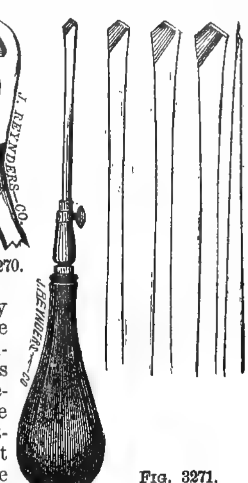


FIG. 3271.

periosteal method, that many operations done under that name are so imperfect as to be worthless as such. The method as employed by Ollier is most careful in details, and the after-care is prolonged and remarkably attentive and painstaking, so that one is left in doubt whether the excellent success in some cases is due to the operative procedure or the after-treatment.

Ollier detaches the periosteum by means of instruments (rugines) much sharper than the periosteal elevators ordinarily in use. They are comparable in this

respect to dull chisels, but are made of various shapes. He maintains that the periosteum should be lifted in its entirety by very careful to-and-fro motions of the tool, and that this can only be accomplished by a rather sharp instrument; a blunt one usually tearing the membrane, bringing away its fibrous part more or less lacerated and shredded, and often leaving behind the bulk of the osteogenetic layer, which alone is valuable for reproduction of bone. To make sure of the removal of this layer, the elevator must be sufficiently sharp and strong to chip the bone when necessary, and whenever he encounters a small prominence or a dimpled surface which is very difficult to enucleate, he slices off a bit of bone with the periosteum, and later on detaches it from within if desirable. As a rule, however, such pieces of bone, if sound and firmly attached, may be well left as aids in the restorative process. A corollary of this last detail is the practice, already alluded to, of leaving a small piéce of bone, if sound, at the point of insertion of a tendon. Every pains is taken to avoid tearing the periosteum or detaching it from its overlying tissues. The same care is exercised in detaching fragments of bone which must be removed in a resection for injury. The whole technique of denudation may be expressed in one phrase: When the elevator has reached the bone, it should never leave it until its work is done. This, in brief, is the sub-periosteal method, and whether it is preferred or not by an operator, it will be readily distinguished from the manœuvres so named in which the periosteum is left behind as a mass of half-connected shreds. In practice it is worth the operator's consideration, to be employed if he thinks he is able in the given case to properly carry it out.

The *bone* to be removed having been denuded by whichever method is selected, it is to be sawn. The slice removed should be, as a rule, as thin as possible. In most joints the end of the bone may be made to protrude through the incision, and the saw is applied outside. If more than one bone is to be sawn, that which is more easily thrust out is sawn first. Great care is to be exercised against unintentional stripping of the soft parts from the bone, although periosteum will generally reunite if kept aseptic. Whatever form of saw is used the soft parts should be perfectly guarded, and metal retractors are usually most convenient and efficient. The saw-cut, especially in places where important vessels or nerves lie near, and more particularly when the bone is not protruded, should not be carried absolutely through the bone, but when it is nearly done the sawing should be slowed, and the fragment be broken off with a pair of forceps or the fingers, or by simply raising it by tilting the blade of the saw. The edge is subsequently trimmed with the cutting forceps or chisel. If the chain-saw be used this last precaution is not so necessary, as the cut comes toward the operator and away from the parts endangered. The chain-saw can easily be introduced by tying the free end to an eyed probe, or to a curved needle, which is then carried beneath the bone. Before beginning to saw, the chain should be carefully straightened, as any kink pretty certainly causes it to break. A common error in its use is the bringing of the two handles too near together, making too short a turn around the bone, which also favors breaking. The hands should be widely separated, so as to make but a slight angle in the chain as it cuts the bone. It is drawn to and fro very steadily, the chain being always kept taut between the hands. While convenient in certain cases, it is a far less perfect tool than the common amputating saw. A very convenient instrument for sawing bone *in situ* is the "Exsector" (Fig. 3272), devised by Gowan, and modified in this country by Wyeth. It combines a powerful grasping forceps with a saw. The latter is at the end of an instrument shaped somewhat like an ordinary screw-driver; it passes through a guide, which again turns on a pivot. The bone-end to be sawed is tightly grasped by the forceps, the saw pushed through the guide until it touches the bone, the handle is moved forward and backward, and the saw-end rapidly cuts the bone cleanly and safely.

In the removal of some joints various devices of coaptation, by sawing the bones into particular shapes—notches, mortise and tenon, etc.—have been employed. They have their advantages, but should not be employed at the expense of sound tissue, and the operator must be prepared to make his decision after he has seen the parts to be removed.

The bones having been sawed, the surfaces are critically examined by eye and touch, to ascertain if the entire amount necessary has been removed. If the resection has been made for disease, this examination reveals any point of bone actually or probably diseased. If found, they are removed by the gouge, chisel, or scoop. If very extensive, a second slice may need to be removed by the saw. All suspected bone, at least in cases of tubercular disease, should be extirpated. It should, however, be borne in mind that the artificial anæmia produced by the elastic bandage may give to the bony surface such a pale or grayish color as to lead to an unduly wide condemnation of bone; in case of real doubt, the elastic band may be loosened. The edges of the bone being made smooth, if, as in the knee, anchylosis is to be sought, the sawed surfaces are approximated, in order to ascertain if the resulting limb will have the right position. If motion is expected, a similar but less close adjustment is generally made, to judge of the probable suitability of the new articulation. This latter precaution is chiefly of value when the excision is for the relief of anchylosis. Any errors in the adjustment of the sawed surfaces are then corrected by the saw or cutting instrument.

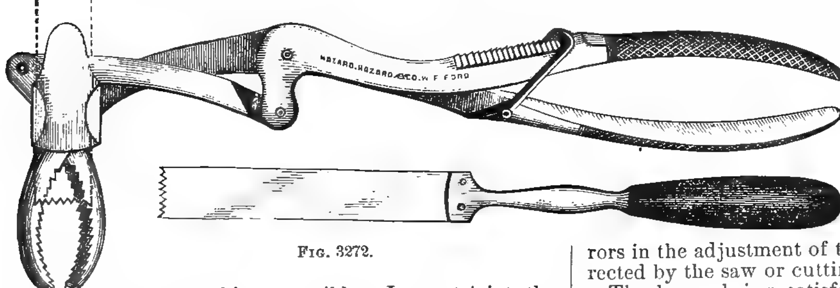


Fig. 3272.

The bones being satisfactorily arranged, the *synovial membrane* is next attended to. All fungous parts are cut away with scissors or scraped with the sharp scoop. As these fungosities are believed to be usually tubercular in their nature, the extirpation cannot be too thorough. If anchylosis is expected, the whole membrane may as well be dissected away, and in any case of doubt it is safer to err on the side of thoroughness. The actual cautery and some cauterants have been used, but their proper place, as applied to synovial membrane, seems to be where the spoon or scissors cannot be employed. As to how far this extirpation should be pushed beyond the synovial membrane—that is to say, to what extent the capsule and ligaments should be sacrificed—authorities are not agreed. Although assent has been given above to the doctrine of thorough extirpation, it cannot be denied that it has sometimes been applied too rigorously. In each step complete examination should precede destruction.

Extirpation completed, the *vessels* are to be looked after. Some may have been recognized as exposed or cut, and twisted or tied at the time. The removal of the Esmarch bandage will reveal any other bleeding points, which will be secured in the usual way, and a hot antiseptic solution will check the oozing. Some operators, when sure that no considerable vessel has been hurt, do not remove (from some joints, at least) the Esmarch bandage until the wound is entirely dressed and the limb has

been placed upon its temporary splint. By so doing the pressure diminishes the amount of oozing, and the demand for drainage is less.

But in all cases the *drainage* must be thorough and complete. The position of the drains should be in such places as to drain the wound whatever position the patient may occupy. Bone-drains are much used for the purpose. It often occurs that after a few days no tubes are needed, and they may be withdrawn and the joint enveloped in its permanent antiseptic dressing. Ollier, whose technique is characterized by the most anxious carefulness, prefers to make his drainage-incisions at the start, because the relations of parts are then undisturbed, and less risk of damage is incurred by making them from without inward thus early. Few operators, however, can tell in advance the extent of the operative cavity that will require drainage with sufficient accuracy to thus early place the drains, and the usual method of waiting till they are needed is, on the whole, probably preferable.

When anchylosis is sought it is more certainly gained, both as to solidity and as to position, if the parts are securely fastened together. As will be shown later, such *fixation* is not absolutely necessary, but is of great convenience. Ordinary suturing materials—silk, catgut, and the like—will serve in case of need; but usually pretty stout wires, either iron, silver, copper, or silvered copper, are employed. To introduce them, bone-drills are necessary. In using the drill it should be carefully passed through one of the bones from its outer surface, beginning an inch (more or less according to the size of the bone) from the sawed surface, in a diagonal direction, so that it perforates the sawed surface sufficiently far from the edge to insure a strong hold. The bones are then placed together in the desired position, so that the point of the drill may show where the other bone must be drilled, and a hole carried from this point out to the surface of the second bone. In this way channels for two or more sutures in the best positions for insuring firmness are made, and the wire, carefully straightened, is carried through. When all are in place the surfaces of the bones are approximated and the wires tightened, and when the former are in the desired position the wires are made as tight as possible and twisted. To avoid difficulty in removal, it is usual to adopt a fixed way of twisting, say from left to right, and to make a certain number of twists, of which a memorandum is kept. This renders the untwisting at the time of removal certain, and no doubt remains in the mind of the operator as to whether he has completely untwisted the wire, or has overdone it and begun to retwist it in the opposite direction. It is now well known, however, that an aseptic wire may be safely left in the tissues, and the precautions above described to get rid of an irritant which tended to prolong the suppuration always attending a resection are now no longer really necessary.

A still further improvement is the use of nails instead of wire to fasten the bones together. They are easier to introduce, and much easier to remove. Nails for the purpose are made by the instrument-makers, and are sometimes plated, an unnecessary refinement. It is an advantage that they should be of steel rather than of iron, as strength and rigidity can be thus had without undue thickness. They may be of round or square wire, and should be very smooth, in order that they may be the more readily made aseptic. They should be of good length, in order that after the necessary penetration for security is had some part of the nail may project through the soft parts to render its removal easy. Preparatory channels are made with the bone-drills, starting from various points on the outer surface of one bone and carried straight on into the other, the two being held in juxtaposition meanwhile. The directions of the nails must not be parallel, in order to prevent the bones drawing apart. This may be assured by introducing the nails diagonally from two or three different aspects of the bone. The nails, which should be very slightly thicker than the drills, are driven into the prepared holes.

Still more convenient are the drills (Fig. 3273) of Dr. Wyeth. They are set in a movable handle. The long, slender shaft is readily introduced, and the handle is then detached, and the drill serves as a nail until the time for its removal arrives.

Howard Marsh[3] recommends the use of bone-pins—bone knitting needles will serve very well—for fastening the bones. It is not necessary to withdraw them if it is not perfectly convenient to do so.

Whatever method of fixation is employed, great pains should be taken to exclude everything from between the sawed surfaces of the bone, whether it be folds of tissue, drainage-tube, or anything else.

In closing the operation-wound, if there be fair reason to expect prompt union, it should be neatly closed except at the drainage-apertures. If, after the extirpation of the disease, the capsule of the joint has been left behind its cut edges may be sewed together with catgut before the outer parts are sutured. If anchylosisand consolidation are lookedfor, the superabundant tissues may be brought together both by deep and superficial continuous sutures.

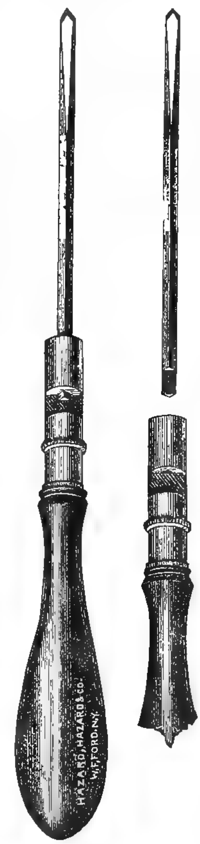


Fig. 3273.

Indications.—The indications for resection vary somewhat with different joints, but the general rules are the same for all. For chronic fungous disease excision is indicated when expectant treatment has failed, and no less extensive operation is sufficient to arrest the progress of the disease. Just what condition of the joint justifies the opinion that expectancy has failed will vary according to circumstances presently to be referred to. But excision should not be considered as a substitute for, or alternative of, expectation ; it may be its sequel in case of failure. This cannot be too strongly insisted on, in view of the tendency of some surgeons to look upon excision as a short road to the cure of chronic joint disease. Nor should the opposite error be adopted, of believing that because among the well-to-do excision is of the greatest rarity such operations are uncalled for elsewhere. In America an intelligent and efficient expectant treatment of joint diseases by rest, fixation, and traction has been so long established that it may seem idle to discuss this point. Not only among the prosperous or comfortable classes is the expectant plan successful, but the result of work done among the poor by the special dispensaries and at clinics is on the whole very satisfactory. But there is, and probably always will be, a certain proportion of cases that cannot or do not get good expectant treatment, or in which it fails. In considering the indication in these cases it is quite irrelevant to urge the success that has attended expectancy in more fortunate ones; they must be considered by themselves. If there is necrosis with a sequestrum of such size as will not readily pass through a fistula, some operative procedure is imperative. But the existence of neither suppuration nor caries, nor the lapse of any particular amount of time, is of itself an indication for resection. A safe rule is this : If, in spite of the best hygiene and the best care that the patient can command, either at home or in charitable institutions, suppuration exists and *persists ;* if there is with it fever, or if the condition of the patient is deteriorating, operative interference of some kind is indicated—either resection or some of its substitutes. It is evident that the decision will be often determined really by what are called the extra-medical indications—that is to say, by the social status of the patient, by what com-

forts he can command during prolonged expectant treatment, and by the necessity of the use of the affected joint in earning his living.

As against amputation, excision is always to be preferred in civil practice, unless the extent of disease threatens that the saved limb will be more useless than a stump would be. As against arthrotomy, with the removal of diseased tissue in an informal manner, no certain rule can be given. Such operations frequently succeed, but relapses demanding excision are also not rare. If the bones be diseased, the removal of the affected parts piecemeal may make a practical resection under another name. The indications for such procedures are very different for different joints, and will be alluded to under those headings. The general rule, however, is that in children, and especially young children, informal resections are to be preferred, the shoulder and hip, perhaps, making exceptions to this rule.

There have been for some time, particularly among German surgeons, many advocates of early excisions. The failures after operations have been considered as largely influenced by delay in operating, and in recent years theories as to the tubercular nature of joint diseases and the success attending aseptic surgery have tended in the same direction. It is held that since fungous joint disease is tuberculous, extirpation is the readiest if not the only certain way of curing it, and at the same time is a safeguard against the generalization of tuberculosis. So that by a single operation the danger to life is diminished and time saved. The tuberculous nature of most fungous joint disease may be conceded, but it is impossible to set inferences regarding the results of tubercular disease against general clinical experience. The latter shows us that, taking one country with another, such joint diseases in the majority of cases do recover without serious operative interference. The vital indication for early excisions therefore fails, unless it can be shown that a larger proportion of cases are cured with excision than without. This has not been shown. Further, it has not been shown that excision, even with antiseptic precautions, has diminished the tendency to other tuberculous diseases. The most considerable contribution to this question is König's.[4] Of 117 excisions of all sorts, made during three and one-half years, 25 died ; 18 from tuberculosis, while 9 others still alive were hopelessly tuberculous. Other less extended lists give similar results. The tubercular infection of the operation-wound is common, although such affections very often yield to secondary extirpation. The operative procedure not rarely explodes some remote tubercular trouble—meningitis, pleurisy, etc.—following within a few days of operation. In respect to tubercular infection of remote parts, the results gained by aseptic surgery have been little, if any, better than were had before.

The existence of pulmonary tuberculosis is generally held to be a contraindication of any resection, but the rule is not absolute. When the pulmonary lesion seems to be secondary to the joint trouble, quiescence of the former occasionally follows the removal of the latter. If the pulmonary tuberculosis is primary, resection is only mischievous.

In acute suppurative arthritis, the success of antiseptic arthrotomy has been such as to make it preferable to excision of the joint. It should, at least, be tried in ordinary cases before resorting to the latter operation.

The results of resection for gunshot fractures of joints are so different in military surgery from those done in civil practice, and vary so much with different joints, that the indications must be given under each head. The same will be done for resections for deformity.

Aseptic methods have diminished the objections, formerly valid, to partial resections, and in gunshot resections the informal, or untypical, methods are usually preferable.

Trophic disturbances of the limb, as distinguished from simple atrophy of inactivity, seem to be more common after gunshot resections than after operations for pathological causes.

Resection of the Shoulder-joint has been long established as a standard operation of surgery. Extraction of fragments of the head of the humerus after gunshot injury had been done for some years, when Charles White,[5] of Manchester, England, in 1768, removed, as he believed, the head and part of the shaft for disease. James Bent, of Newcastle, England, published, in 1774[6] an account of a true excision of the head of the humerus for disease. He pointed out the fact that Mr. White had not removed the head, and that the bone removed at the first operation ended at the epiphyseal line. White's report and plate seem to justify this criticism, although his claim was made in good faith. Bent (1771) or Lentin (1771), probably, should have the credit of priority. The first complete excision of the shoulder is attributed to the elder Moreau (1786). Larrey seems to have first introduced excision of the shoulder into military surgery in the Egyptian campaign (1798). Thereafter the operation gained in professional esteem, and on the Continent its value may be said to have been established by the experience of the Schleswig-Holstein campaign of 1848, the Crimean war (1855), and in this country by our own war (1861–65).

Owing to the relative infrequency of disease of the shoulder,* as compared with other joints, operations for disease are far less numerous than for gunshot wounds. Culbertson collected 855 cases of excision for gunshot wounds, 12 for other injuries, and 116 for disease.

The mortality of resection for gunshot injury of the shoulder-joint is not relatively high, being, according to Culbertson, for all operations, complete and partial, 31.44 per cent., most of the observations belonging to the pre-aseptic period. Operations for disease give a still smaller mortality. The same author gives (omitting cases of malignant disease) 101 cases, with 16 deaths, or 15.84 per cent. Otis[7] gives the comparative mortality for gunshot injuries of the shoulder thus: "Of 2,369 determined cases, 577 were treated by expectancy, with a mortality of 25.1 per cent.; 951 by excision, with a mortality of 36.6 per cent.; 841 by amputation, with a mortality of 29.1 per cent.—in all, 738 cases terminating fatally, or 31.1 per cent." The statistics of more recent wars, as far as attainable, seem to show no great variation from the above.

In civil practice, under modern methods, resection undoubtedly gives a smaller death-rate, but no extended statistics can be given.

Results.—While it appears that the immediate mortality of resection of the shoulder-joint is somewhat greater than that of amputation for gunshot injury, the incomparably better result—the saving of an arm—in case of success, has made resection of the shoulder one of the triumphs of military surgery. To escape amputation is to save a hand and elbow, even if the functions of the shoulder-joint are seriously impaired. Gurlt[8] gives the functional results of resections made in German wars between 1848 and 1871. He divides them into five classes: I., "very good," those which are perfect or as perfect as is possible; II., "good" results, not perfect, but members very useful; III., "middling," members of some use, but perhaps needing artificial support; IV., "bad," members not useful; V., "very bad," not only not useful, but burdensome. Of 213 cases of shoulder resection, the percentage of results is: I., 1.87; II., 42.25; III., 47.88; IV., 7.98; V., 0; or, roughly, good, 44 per cent.; middling, 48 per cent.; bad, 8 per cent. Remarkably useful shoulders are sometimes obtained, as witness cases figured by Langenbeck,[9] or the case reported by MacCormac[10] of a Chasseur d'Afrique injured at Sedan from whom, twelve days later, he removed the shoulder and elbow joints of the right arm. The strength and utility of the arm were remarkable (see Fig. 3274, showing limb passive and active).

A common imperfection of result, both at the shoulder and elbow, is preternatural mobility, or "flail-joint." In spite of this want of firmness at the shoulder, the arm is often very useful. Gurlt found, in the cases before al-

* The writer has added the lists of several hospitals, American and foreign. Of 1,368 cases of joint diseases, 22 only were of the shoulder—less than two per cent. In one hospital, for one year, there were 10 out of 320 cases; in another, only 5 out of 540—that is, about three per cent. of all cases for the highest, one per cent for the lowest.

luded to: Closely knit joints, 45.07 per cent.; flail-joints, 35.68 per cent.; anchylosed joints, 9.86 per cent.; unknown but not anchylosed, 9.39 per cent. There is little doubt that the careful sub-periosteal resections urged by Langenbeck and Ollier give much better results as to flail-joint, as well as in other respects, than the older methods. Not only is the muscular structure less damaged, but the reproduced bone gives a better *point d'appui*, the loss of which has been considered a main reason for the difficulty in raising the arm above the horizontal.

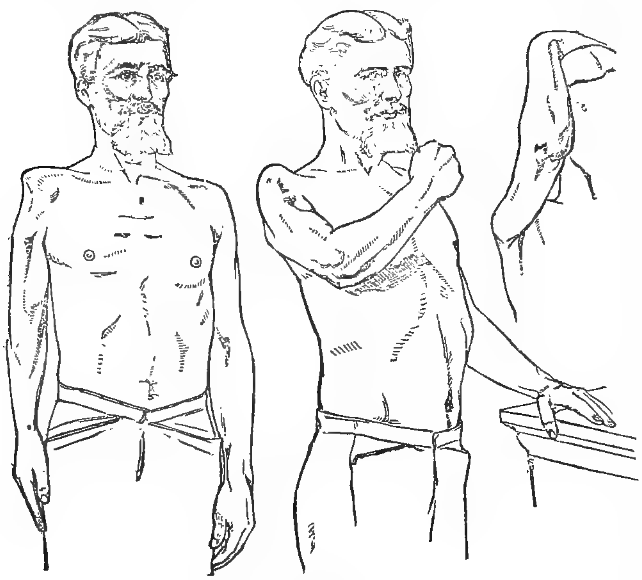


Fig. 3274.

Indications.—The experience of the war of the Rebellion and of the German wars between 1848 and 1871, as analyzed by Otis [11] and Von Langenbeck, [12] goes far to settle the indications in gunshot injury of the shoulder. If the injury is slight, expectant treatment is justifiable, even if a secondary resection becomes subsequently necessary. In cases in which a part only of the head has been broken off by the shot, partial excisions, *i.e.*, removal of the injured part only, have succeeded. If extensive (comminuted) fracture of the head exists, or the ball is impacted, the main vessels and nerves being sound, primary resection is indicated. "Concomitant fractures of the acromial end of the clavicle, or of the neck, or processes of the scapula, or of the upper third of the humerus, do not necessarily contraindicate excisions at the shoulder" (Otis). Nor, according to Langenbeck, does shattering of the shoulder-joint with laceration of the soft parts necessarily indicate exarticulation, but rather a secondary resection. "Intermediary resections should seldom or never be practised" (Otis). Injury of the axillary nerves and vessels complicating shot-wound of the shoulder usually calls for exarticulation.

Resection has also been held as indicated in compound dislocation, in compound fracture with protrusion of fragments, and in some forms of laceration of joint-structure. The success of aseptic dressings, however, has made these indications less distinct than formerly, and if reduction can be accomplished and asepsis insured, the surgeon may decide between resection, or the aseptic expectant treatment and subsequent osteotomy in case of too rigid anchylosis resulting.

For fungous arthritis resection is demanded when expectant treatment has not succeeded and the strength of the patient is failing. There is then a vital indication for interference. If on the joint being opened the bony parts are found to be not involved to any extent, gouging and scraping may suffice, but the relative advantages of informal operations over the formal are not so great at the shoulder as in some other articulations. The great success of resection justifies its use in any case in which there exists much risk to life from exhaustion or from the sequels or complications of prolonged suppuration. Functionally, the results of resection are not so much superior to those of cure by anchylosis, more or less complete, as might be at first thought. Owing to the mobility of the scapula, a great deal of motion is permitted to the arm, even if no motion takes place at the shoulder proper, and in some excellent results with motion after resection the portion of the mobility furnished by the sliding scapula has been found to far exceed that in the joint itself. This is, however, not always true, but the facts stated have led some surgeons to advocate the securing of cure by anchylosis if practicable, rather than by resection, and to make subsequent osteotomy, if necessary, as before mentioned. This supplementary mobility being greatest in the very young, the age of the patient may determine the surgeon's choice of procedure.

Methods.—Very many forms of incision have been employed for the removal of the head of the humerus, such as the **V**, the **U**, the **T**, the **˥**, single or double and inverted, and others, but practically, when the surgeon has a choice, all have now given place to the anterior longitudinal incision. The injury, particularly if a gunshot wound, for which the resection is performed, may have determined site of the operative wound, or if the muscular the cap of the shoulder is already badly torn, little additional damage will be done by making use of the same opening for the removal of the bone. But in the operation for disease, or whenever the surgeon may choose, the straight anterior cut is to be preferred because of the less injury it inflicts upon the muscles. The two varieties of this incision are Langenbeck's and Ollier's. Langenbeck's original procedure has been modified by him so as to become a sub-periosteal method. The first is as follows: [13] The patient lies upon his back, with the shoulder raised upon a pillow; the arm is held so that the external condyle of the humerus is directed forward. An incision, beginning at the anterior border of the acromion, quite close to its articulation with the clavicle, and running for six to ten centimetres (2½ to 4 inches) vertically downward, divides the deltoid muscle and reaches the capsule of the joint and the periosteum (Fig. 3275). The muscle is retracted on both sides of the incision; the tendon of the long head of the biceps is seen lying within its sheath. An incision along the outer side of the tendon opens its sheath; the knife is directed upward with the back of the blade in the bicipital groove, and divides the whole length of the sheath, together with the capsular ligament up to the acromion.

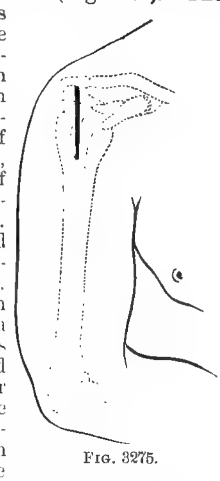


Fig. 3275.

The tendon of the biceps is lifted out of its groove and drawn outward with the blunt retractor. While the assistant rotates the arm outward, a curved incision, with a strong knife placed at right angles upon the bone, is carried around from the opening in the joint over the lesser tuberosity, dividing the capsular ligament and subscapularis muscle. The arm being again rotated inward, the tendon of the biceps is also drawn inward over the head of the bone. The knife is again carried around in a larger circle over the greater tuberosity and divides the capsule together with the insertions of the supra-spinatus, infra-spinatus, and teres minor. The head of the humerus is forced out of the wound by pressure from below, seized with the forceps, and after the posterior insertion of the capsule has been divided, removed with the keyhole saw. When the head of the humerus is separated from the diaphysis by the bullet, it must be drawn forward, and fixed by a sharp

bone-hook or bullet-screw. If shattered in many pieces, the fragments are removed separately.

Better results, however, are obtained by the use of the sub-periosteal method. The incision, described in the paragraph but one above, having been made, the periosteum is divided with the bone-knife along the inner border of the bicipital groove, and carefully raised with a narrow elevator from the lesser tuberosity. The tendon of the subscapularis is pulled from the bone with the knife and toothed forceps, without separating the fibrous capsular ligament from the liberated periosteum. During this part of the operation the humerus must be slowly rotated outward, and as it becomes more and more liberated, the knife is frequently changed for the elevator. The arm is rotated inward again, the tendon of the biceps lifted from its groove, and slipped over the head of the bone to its inner side. The periosteum on the outer surface of the neck of the humerus, together with the insertion of the supra-spinatus, infra-spinatus, and teres minor into the great tuberosity, are detached in the same manner as before. This preservation of the periosteum is rather difficult in primary excisions for gun-shot injury, because it is usually normally so thin. The head of the humerus is forced out of the wound and sawn off as in the preceding operation. If only the head above the tuberosities is to be excised (which always gives the best result), there can be no question about detaching the periosteum. Beginning from the interior of the joint the muscular attachments are peeled off from the bone as far as is requisite; care is taken that they are not divided transversely, but that their connection with the bone below is preserved. The head must be removed *in situ* with the keyhole, or chain-saw.

Ollier's [14] method differs somewhat from the preceding, and is as follows: The elbow is abducted nearly to a right angle. The incision is made in the interspace between the pectoralis major and the deltoid, or, if this is not easily recognized, from the point of the coracoid process downward and outward in the direction of the fibres of the deltoid. If the border of the deltoid is recognized the incision should slightly encroach upon the muscle in order to avoid the cephalic vein, which last should be left in the inner lip of the wound. The edges being retracted, the head of the humerus is exposed. The capsule is opened by carrying the incision through it outside of and parallel to the tendon of the biceps (long head). The same incision divides the periosteum as far as required. The outer lip of the wound is raised, the periosteum detached by the sharp periosteotome, the bone being inverted by an assistant. All the attached muscles are raised with the periosteum. The arm is then everted and the bone denuded on the inner side. The head of the bone is then luxated, the posterior part of the capsule detached, the neck denuded. The bone is then sawn with any saw preferred.

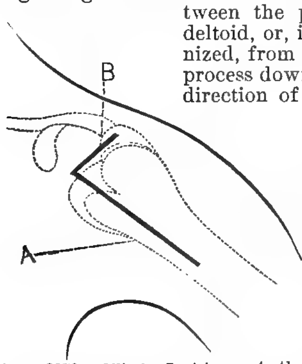


Fig. 3276.—Ollier's Incision. *A*, the principal incision; *B*, cross incision if necessary for excision of glenoid cavity, etc.

After-treatment.—No splint is really necessary, the aseptic dressing and shoulder spica being sufficient, while the patient is recumbent. The arm should preferably be abducted at first. If it is found desirable that the patient sit or walk, an axillary cushion and sling, or a plaster bandage will be needed for support. Passive motion must be begun early, as soon as the tissues are well consolidated. Persistent care is essential to the best results.

Resection of the Elbow appears to have been one of the earliest of resections, Wainman having, in 1759, resected the lower end of the humerus for a compound luxation of the elbow, and Filkin having excised this joint for disease three years later. But like other excisions it came slowly into general use. Symes' advocacy of the operation had considerable influence among British and American surgeons, and during the following twenty or thirty years it became established in civil practice; while the wars on both continents from 1848 to 1871 gave large opportunities for testing its merits in military surgery.

Results.—Culbertson gives the following percentages of mortality as the result of his table of cases, mainly from the pre-antiseptic period. For gunshot wounds, "partial" excision, 27.02 per cent.; for "complete," 25.30 per cent. For injury, "partial," 7.40 per cent.; "complete," 21.05 per cent. For disease, "partial," 11.11 per cent.; "complete," 9.94 per cent. In this classification only those resections are considered "complete" in which the lower end of the humerus with the upper ends of the radius and ulna, or of the ulna alone, are removed. Removal of head of the radius with the lower end of the humerus is considered a "partial" operation. These figures as regards resections for gunshot injuries are not much different from those of Gurlt, who gives 27.41 per cent. for all operations by German operators in the war of 1870–71, and 26.64 per cent. for the German wars 1848–71. These percentages with that of our own war (23.70) give a total percentage of mortality for all operations of 25.10; the complete operations giving 25.40 per cent.; partial, 23.07 per cent.; operations of unknown extent, 30.60 per cent. Partial operations were much more frequent during our own war than in the German wars. Otis's tables show that the time of operation in our war very much modified the death-rate; it being for determined cases only, primary operations, 21.3 per cent.; intermediary, 35.2 per cent.; secondary, 9.2 per cent.; time unknown, 8.3 per cent. The total mortality of elbow resection in our war, 23.7 per cent., may be compared with that of amputation in the upper arm, which was 23.6 per cent.* The comparatively low death-rate of operations for disease (10.4 per cent.) for all of Culbertson's cases will be noted, but no extended statistics are at hand to show how great the purely operative mortality is, and how much is to be attributed to the progress of the disease. That under favorable circumstances the mortality is very slight is shown by the fact that Culbertson gives no deaths for excision for deformity, and Salzman (quoted by Ollier) puts the mortality of resection for anchylosis at 1.47 per cent.† Age affects mortality, the death-rate being for disease least between ten and twenty years of age; for gunshot injury least between twenty and twenty-five years of age. The relative fewness of soldiers under twenty, and the inability of the immature to bear the hardship of campaigning, account probably for the greater percentage of mortality between fifteen and twenty.

The functional results of resection of the elbow are, in civil practice, in general, very good. The joint is not infrequently nearly perfect in function, and strong enough for ordinary occupations, and sometimes even for laborious work. The precise degree of success cannot certainly be made out from statistics, as in some groups the ultimate result is wanting in a large proportion of cases (*e.g.*, Culbertson, excision for gunshot injury, 62.86 per cent., "not stated"). Culbertson gives 40 cases of recovery from "partial" resections for disease, with 6 "perfect" and 32 "useful" joints, together 80 per cent. Of 290 recovered "complete" resections, 32 were "perfect," 196 "useful," together 78.6 per cent. The pension inspections have given opportunities for critically observing the remote results of resected joints, and Gurlt gives the following for the resections of the elbows made in the German wars from 1848 to 1871, the classification being the same as for shoulder resections given above: Very good, 5.63 per cent.; good, 23.66 per cent.; mid-

* For the lower third of the arm only, 35.2 per cent.

† Ollier (Revue de Chirurgie, 1882, p. 717) says that in a series of fifty cases since 1876 he has had no death attributable to the operation. Previous to 1876 he had twelve deaths in sixty-three operations. The improvement he attributes to asepsis and earlier operations, which render the operation less extensive in patients less exhausted.

dling, 53.24 per cent.; bad, 14.37 per cent.; very bad, 3.09 per cent.

The restoration of the resected parts is often quite extensive, and many autopsies have been made upon such restored joints. Nepveu [15] has collected some twenty-one observations. The commonest peculiarities are forked or malleoli-like developments of the condyles, or instead an olecranon-like prolongation of the humerus. The olecranon is sometimes absent, and its place supplied by a radial or humeral prolongation. The coronoid process is often absent. There is usually some restoration of cartilage. The general form of the new joint is similar to that of the ankle.

Indications.—Resection was formerly held to be indicated whenever in a gunshot wound of the elbow the bones were found to be implicated, while the extent of the injury did not make amputation the preferable operation. More recent experience has made the indication less absolute. Otis [16] expresses the result of the latest extensive military experience when he says: "1. That in shot wounds in young healthy subjects, attended with slight injury of the articular extremities of the bones of the elbow, such as fractures of the olecranon, of the outer condyle, or of the trochlea, without much splintering and without lesion of important vessels and nerves, it is justifiable, in many instances, to attempt an expectant conservative treatment, keeping the injured extremity in entire rest, after removing any detached fragments or foreign bodies, in a semi-prone and very slightly flexed position, employing ice or other cold applications." If inflammation occurs it should be met by drainage and appropriate treatment, and if necessary secondary operations resorted to. "Unless all the favorable conditions mentioned are present at the outset, it would be safer to resort to primary excision or amputation. 2. In grave shot comminutions with lesion of the principal vessels or nerves, amputation should be practised immediately after the reception of the injury. 3. In severe shot fracture without extensive lesions of the soft parts, the joint should be freely exposed by a longitudinal posterior incision, and the full extent of the fracture ascertained. Unless there is extraordinary fissuring, the injured joint ends should then be sawn off as close to the limits of the injury as possible, save that the bones of the forearm should be shortened to the same level. If the splintering extends very far, or if there is reason to believe that the humeral vessels are injured though not wounded, the incisions should be so modified as to convert the operation into an amputation." If by reason of the success of aseptic dressing the above needs modification, it is only in enlarging somewhat the range of cases amenable to expectant treatment and in diminishing the weight that splintering of bones gives to the indication for amputation.

For disease, after infancy has passed, resection is indicated, as in other joints, whenever it is clear that expectancy has failed or will fail; that is to say, whenever the best treatment and hygiene at the command of the patient has not arrested the advance of the disease, or if after prolonged trial no material improvement has occurred. While not absolutely indicated, resection is also worth considering if, although the case is progressing toward cure by anchylosis, the position in which anchylosis must occur will be a disadvantageous one. Anchylosis at the shoulder is palliated by the mobility of the scapula, at the wrist, the tendons being free, by the mobility of the fingers. At the elbow there is no considerable compensation, and the very complex function of this joint makes anchylosis of it often very embarrassing.

For anchylosis actually existing resection seems to be indicated in the young, that is to say, until the age of twenty or twenty-five years, if the position of the joint is decidedly disabling, as, for instance, that of total extension. The indication is increased in strength by the existence of double anchylosis, especially if symmetrical as to position. If the two joints be flexed at different angles, the sufferer may be able to perform many of his duties; but a symmetrical anchylosis usually materially disables him.* In such a case excision might be indicated even if anchylosis in a better position were the only gain. It should be borne in mind that the lower epiphysis of the humerus and the upper epiphyses of the radius and ulna contribute but a small part of the growth of the arm. Ollier thinks about one-tenth of the total growth, so that resection of the elbow in early life does not greatly shorten the limb. In adult life excision for anchylosis gives less satisfactory results. In every case of anchylosis the condition of the muscles as to vitality and possible redevelopment must be considered before resection is determined upon.

For gunshot wounds total resections have been considered indicated. The experience of our own war and, to a certain extent, that of the Franco-German war has shown, however, that under favorable circumstances partial operations may do well. For disease the rule is the same, although partial resections of late years are found to be less disadvantageous than formerly supposed. In childhood informal resections have grown in favor; many German operators urging them in place of typical resections.

For anchylosis the resection must be total. But as the age increases the power of reproducing bone diminishes, and consequently in adult life the bone cannot be so freely removed as in youth without endangering flail-joint.

Methods.—Many forms of incision have been employed, and as far as can be judged from Culbertson's statistics no marked difference in results follows the different incisions. The incision of Liston (⊢, the longitudinal part being along the inner border of the olecranon and the transverse portion across the back of that process to the lower border of the external condyle) has been much employed, but at present single longitudinal incisions are deemed to be in ordinary cases sufficient. If the form of the existing wound or other reasons make it preferable some other incision should be employed. Of the longitudinal incisions Langenbeck's subperiosteal method is probably the most frequently resorted to. It is as follows: [17] An incision eight or ten centimetres in length is made over the extensor surface of the joint, somewhat to the inner side of the middle of the olecranon, the tip of the olecranon being above the centre of the cut. (See Fig. 3277 in which the incision is placed too high.) This cut goes down to the bone throughout its course. The periosteum is first elevated toward the inner side and the inner half of the tenden of the triceps, together with the periosteum, is divided by short parallel longitudinal incisions directed against the bone. The soft parts, covering the internal condyle and inclosing the ulnar nerve, are drawn by the left thumb-nail toward the tip of the epicondyle, and liberated by curved incisions close together and against the bone until the epicondyle is completely exposed. The last incisions are carried around this prominence and separate the origins of the flexor muscles as well as the internal lateral ligament from the humerus, without however disturbing their connection with the periosteum. The tissues are replaced and the outer part of the tendon of the triceps and the anconeus are detached with the periosteum, and in the same careful way described the capsule is raised and the external condyle reached and cleared, the external lateral ligament and the extensor muscles being raised with the periosteum of the humerus. Both condyles being free, the joint is

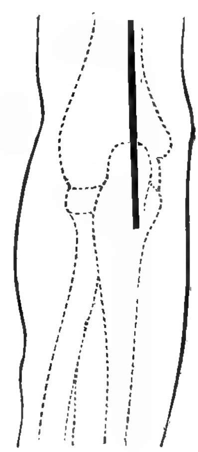


FIG. 3277.—Langenbeck's Incision.

* Double anchylosis appears to be most common as a sequel to small-pox. Such cases are frequently referred to in continental articles, and the writer has met with two cases from this cause.

forcibly flexed, the articular surfaces forced out of the wound. The humerus is steadied with the forceps and the articular surface sawn off. The ulna and the radius are then sawn. If it be necessary to go below the coronoid process, the upper fibres of the brachialis anticus must be divided, without destroying the connection of the tendon with the periosteum of the ulna.

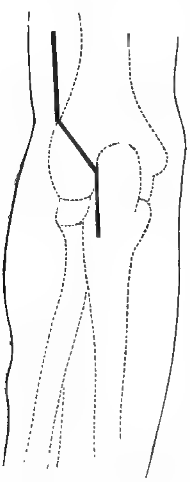


FIG. 3278.—Ollier's Incision.

Ollier employs the "bayonet" incision (Fig. 3278) as calculated to do the least injury to the soft parts. It is made thus:[18] Commence the incision on the external border of the arm six centimetres above the line of the articulations; carry it down to the level of the prominence of the epicondyle; thence turn it downward and inward to the olecranon. The direction of the knife is again changed and follows the posterior border of the ulna for four or five centimetres according to the amount of bone to be removed. This last part may be carried at once to the bone. Above the aponeurosis should be divided and the incision carried between the triceps on the one side and the supinator longus and the extensor carpi radialis longior on the other. The division of the capsule follows the external incision. The oblique part of the latter corresponds nearly to the interval between the triceps and anconeus. The internal lip of the wound with the triceps is detached, the connection of the tendon with the periosteum being carefully preserved. The external condyle is then cleared, the humerus luxated backward, the denudation completed, and the bone saw off. The bones of the forearm are then denuded and divided with saw or cutting forceps. It is usually better to begin with the radius.

When the operation is done for anchylosis Ollier sometimes finds it necessary to make a long radial incision and a small one on the ulnar side. The bone is sawn from behind forward nearly through and broken. This procedure somewhat resembles that of Hueter given below.

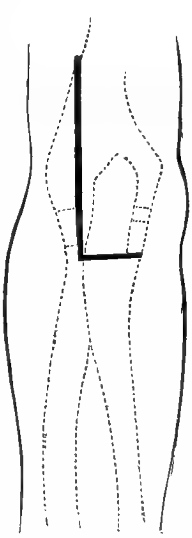


FIG. 3279.—Nélaton's Incision.

Nélaton used a radial incision with a transverse cut across the olecranon (Fig. 3279). The head of the radius is first exposed and sawn off. The olecranon is then denuded and the triceps tendon detached. The forearm is bent inward, the ulna protruded and sawn. The humerus is then easily protruded, denuded and sawn.

Hueter,[19] to avoid the division of the triceps tendon and facilitate the enucleation of the olecranon without disturbing the relations of the tendon to the periosteum and fascia, used the following method. A preliminary longitudinal incision (Fig. 3280), about half an inch in length, is made over the prominence of the internal epicondyle, or rather more in front to more certainly avoid the ulnar nerve. A circular cut around the base of the epicondyle detaches the muscles and divides the internal lateral ligament. The principal incision is made on the radial side. The knife is entered above the external epicondyle and carried straight down over that prominence, opening the joint and exposing the head of the radius, the lateral ligament being divided longitudinally and the annular ligament transversely. The head of the radius is easily freed and sawn off with the keyhole-saw and extracted. The left forefinger is then passed into the joint and the anterior part of the capsule made tense while it is detached from the bone with the knife or elevator. The finger is then passed behind, stretching the triceps tendon, which is detached in the same manner. It is not easy to clear the inner border of the humerus in this way, but by forced abduction of the forearm the ulna is dislocated inward and the humerus thrown out of the wound, where it is easily denuded as far as necessary and sawn off. The ulna is then brought into the centre of the incision, examined, and the triceps separated from above downward by short firm strokes of the knife or elevator, and the olecranon shelled out of its fibrous envelope until the necessary amount is denuded, when the bone is sawn.

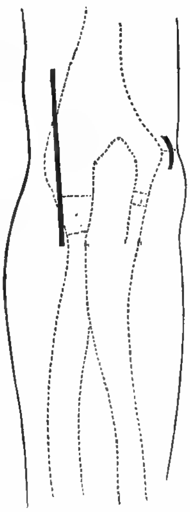


FIG. 3280.—Hueter's Incisions.

Von Bruns, as early as 1858, proposed osteoplastic resection of the elbow, by making use of temporary division of the olecranon, the sawn surfaces being reunited at the close of the operation. Originally this device was directed to the management of ancient dislocations or to compound dislocations. Other German operators have extended the use of the osteoplastic method to resection for foreign bodies in the joint, and have even employed it in operations for disease. This last application has been, by some surgeons, held to be unwise, owing to the frequency of disease of the olecranon, but there seems to be no impropriety in making section of the olecranon in doubtful cases, and removing the diseased bone entirely, if, after inspection, this course seems to be preferable. The methods employed for osteoplastic resection have been various, but the two given are as simple and apparently as successful as any. Fig. 3281 shows the incision of Von Mosetig-Moorhof.[20] The elbow being slightly bent the incision is carried from the lowest point of the external condyle across the base of the olecranon to its inner margin. From the end of this cut another runs at first parallel to the inner margin of the olecranon, and then curves slightly inward to a point about a finger breadth above the tip of the bone. The ulnar nerve is dissected out and drawn aside, the olecranon divided and turned up in the flap. The humerus is cleared and sawn off below the epicondyles, the head of the radius taken off, the olecranon scraped to sound tissue, and its sawn surfaces reunited with silver wire.

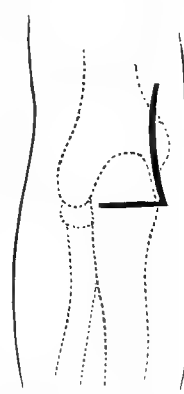


FIG. 3281.—Von Mosetig-Moorhof's Incision.

Stimson[21] avoids meddling with the ulnar nerve by combining the lower two-thirds of Ollier's incision with a transverse one across the base of the olecranon (Fig. 3282), and sawing the latter somewhat obliquely, from below upward, into the joint. The joint is then further opened through the lateral incision, the external condyle denuded and the flap, including the upper part of the olecranon, turned upward and inward. The humerus is then denuded and

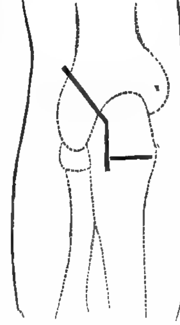


FIG. 3282.—Stimson's Incision.

sawn off through the epicondyles, the radius protruded and sawn through the neck, the diseased part of the ulna scraped, the capsule dissected out, and the parts of the olecranon reunited by silver suture.

It will be noticed that while many of the older operations, Liston's, for instance, were upon the ulnar side, and Langenbeck's is central, that the majority of the more recent operations, if not bilateral, are mainly upon the radial side.

In operating for anchylosis, if the union can be broken up, and frequently where it cannot be, the single incisions will usually suffice. Occasionally bilateral incisions are called for. Many operations have been devised, and methods for meeting the indications of special cases, but space forbids detailing such.

The after-treatment is important. The position preferable is that of very slight flexion, or perhaps, as Roser urges, for some time in extension, as giving more compact restoration of the soft parts. No splint is more generally acceptable than a well-applied gypsum bandage, bracketed or not, as the condition of the wound may render desirable. At first a very firm antiseptic dressing may suffice in place of splint. In the very young early motion is advisable, but in adults there is much less danger of anchylosis than of flail-joint, and passive motion may be delayed until a moderate degree of firmness in the tissues has been reached.

Resection of the Wrist.—The earliest operation of this kind known was for injury, Mr. Cooper, of Bungay, having, in 1750,* removed the lower ends of the radius and ulna for a compound dislocation. In 1762 Bagieu excised the joint for gunshot wound. The first resection for disease was in 1794, when the elder Moreau performed it. Operations were few until about 1840, since which time they have been more frequent. Nothing has ever done so much to establish the operation as the paper of Mr. Lister,[22] published in 1865, detailing an improved procedure, and giving the encouraging results of fifteen cases in which he had employed it. Resection of the wrist, however, has never enjoyed the popularity among surgeons that has been accorded to similar operations on some other joints. No one to-day would endorse Malgaigne's wholesale condemnation, but many grant the operation but limited approval. This is not due to a high death-rate, for, according to Culbertson,[23] the mortality proper to the operation for all causes is but 1.73 per cent. The failure of the resection in many cases to arrest the local process, or to hinder the development of kindred maladies, and the frequent worthlessness of the hand when saved, are responsible for this distrust. A glance at the anatomy of the wrist will show that the complex synovial sacs, and their relations to the many small bones, and the proximity of the numerous tendinous sheaths, favor the spread of disease and hinder its extirpation, except by an extensive and careful operation; while prolonged suppuration would very probably set up such adhesions of tendons as to permanently destroy the usefulness of the remains of the hand. Until a comparatively recent time, surgeons had not the technical resources to satisfactorily deal with the problem. It seems, too, that the operation has not been quite fairly dealt with, in that a tendency is shown to compare the functional results obtained with the perfect hand, and not, as should be done, with those of other operations, such as scooping or amputation.

There has been an unusual want of agreement among writers as to what constitutes a complete, and what a partial, resection of the wrist. Strictly speaking, the wrist means the radio-carpal articulation, but by extension it has come to include in this connection both the medio-carpal and the carpo-meto-carpal articulations as well. The most reasonable definition seems to be that a complete resection of the wrist must include the removal of the lower articular extremities of the bones of the forearm, or at least of the radius on the one side, and of the first row of carpal bones, except perhaps the pisiform, on the other. More may be removed in a complete resection, but less would make it partial, *i.e.*, to be complete both members of the radio-carpal joint must be removed.

Results.—The functional results of wrist exsection are very often very vaguely stated by reporters. So far as they can be separated, they may be divided into bad, indifferent, and satisfactory. By "bad" is intended that the limb is worthless and was subsequently amputated; by "indifferent," a hand of limited usefulness, the impaired mobility of the fingers preventing any work demanding delicacy or strength; by "satisfactory" is meant that there is mobility of all the fingers, that the opposition of the thumb is preserved, and that the person can write, sew, and do similar things requiring dexterity, and that, in some cases at least, the hand has sufficient strength for more laborious work, such as driving, the use of moderately heavy tools, or for the support of several pounds weight. In Culbertson's extensive tables of 58 excisions for gunshot wounds, 1 gave "perfect" result; 16 "useful" hand; 8 "not useful;" 2 "amputated;" 31 "not stated." Of 14 operations for injury, 4 are "perfect;" 8 "useful;" 2 "not stated." Of 79 operations for disease, 6 are "perfect;" 36 "useful;" 11 "not useful;" 10 "amputated;" 16 "not stated." These were all, or nearly, done without aseptic precautions.

Nepveu[24] has collated the final results in 36 cases, some of which are more recent than those in Culbertson's table. In 8 cases the result was absolutely bad, in 13 indifferent, in 15 really satisfactory.

Ollier[25] thinks that even better results than those usually considered "satisfactory" should be looked for. One of his patients, from whom he removed all the carpal bones but the pisiform, the articular surface and styloid process of the ulna, lower extremity of the second, fourth, and fifth metacarpal bones, and the whole of the third with its finger, two years after the operation could hold out at arm's length, for some seconds, a weight of ten kilogrammes—about twenty pounds. A second traumatic case, after eleven years, held out eleven kilos and was skilful on the trapeze, played the cornet, and was employed as a notary's clerk, writing all day without fatigue. In the latter case the operation was done for gunshot injury, the shot passing transversely through the wrist and severing the radial artery.[26]

Experience in the field has not been very encouraging, but nearly all of the records are based upon experience previous to 1865, before which date the status of the operation, as to technique and in other respects, was unfavorable to success. In the War of the Rebellion, of six complete excisions of the wrist, one proved fatal after recourse had been had to amputation in the forearm. The five others recovered with functions of the hand much impaired, but, all things taken into consideration, in a better condition than if they had been subjected to amputation.[27]

Gurlt's tables show that, of recovered cases of resection of the wrist in military surgery, none belong to his class of "very good;" 6.25 per cent. were "good," 50 per cent. "medium," 37.50 per cent. "bad," 6.25 per cent. "very bad." The same authority gives the mortality of primary resection as 10.25 per cent.; intermediary, 30 per cent.; secondary, 22.22 per cent.; total mortality in 126 cases, 16 per cent.

Partial excision, and mixed operation in which portions of the hand were removed, gave but indifferent results on the whole; but even these imperfect members, especially with proper supports, were usually more useful than the stump of amputation could be made to be.

Resection for anchylosis of wrist has been done. The one case (Langenbeck's) of which this writer knows the result was not successful, the anchylosis recurring.[28]

In general, anchylosis is frequent and flail-joint rare. The hand in many cases is distorted toward the radial side. Both the anchylosis and distortion are probably largely due to incomplete after-treatment. Dorsal flexion is naturally usually imperfect, owing to the normal predominance of the flexors over the extensors. It is asserted by some German authorities that soldiers some-

* This date is given in some books; Gooch, in 1767, alluded to the operation as occurring "many years ago."

times wilfully neglect after-treatment, lest their pension should be diminished.

Indications.—For injury, as compared with amputation, resection is always to be preferred, unless hopeless damage has been done to the tissues, especially to vessels and nerves. In civil practice the prognosis is excellent as to life, and as to function, it should always be remembered that a very indifferent hand is much better than none. There is good reason to believe that, with the simplification of aseptic dressings, very much better results can now be expected in military practice than heretofore.

In military surgery informal resections are now thought to be preferable. But nowhere is great attention to detail, the removal of hopelessly detached fragments, cleansing, tendon suture, etc., more necessary than in these operations.

In compound fractures and in compound dislocations the same careful informal operations are to be preferred.

For disease (caries) resection is indicated if expectant treatment has failed, but the rule is to be applied here with more limitation than to some other joints. Practically, resection is never called for during the first five years of life, and rarely before puberty, as less formal or less extensive operations take its place. In very young children the actual cautery, used through fistulæ or carried down knife-wise into the boggy and fungous tissues, is often followed by a marked improvement, with retrogression of the fungoid changes. Still later, *i.e.*, until about the age of puberty, the excavation of diseased parts by the scoop or periosteotome (conjoined with the actual cautery in parts which cannot be easily reached, or which the operator prefers to leave untouched by the instrument), and free drainage and compression, are followed by the happiest results and, probably, by more useful hands than could have been gained by formal resection. This last method, however, should not be made to include too niggardly openings. Sufficient room should be allowed for proper inspection of the parts, etc. After puberty, and during the first half of life, resection in form has its best results. The excavation may still succeed, but its special province is during the growing period of bone, while it still has great reparative vitality. After thirty-five or forty years resection is not forbidden, but its functional results are less brilliant.* The existence of caries of the carpus in adult life is often associated with tuberculosis elsewhere. This is generally considered as a contra-indication of resection, but in young adults resection is not rarely followed by a recession of pulmonary signs, and the operator must critically examine the history of the case as to the probable dependence of the general condition upon the local one, before deciding between resection or amputation. The existence of fungosities in the sheath of the tendons in adult cases is generally considered a strong contra-indication of resection, owing to the small chance of good functional results.

Operative Methods.—The back and sides of the wrist contain no important vessels or nerves, and the skin and tendons only overlie the joint structures. All operations on the joint are therefore preferably begun from these aspects. The radial artery winds into the dorsal aspect, but can be usually managed without damage. The injury done, in the older methods of excision, to the extensor tendons both by the operation itself and the prolonged suppuration, is largely accountable for the poor results obtained. At present the longitudinal incisions, single or double, have practically displaced all others; and the admirable method of Mr. Lister is by far that most frequently employed, at least by English-speaking surgeons. Although the case which seems first to have fixed Mr. Lister's attention upon the subject was a traumatic one, his paper is confined to the consideration of excision for caries. The description below is slightly abbreviated from this paper.[29] The operation elaborated by this great surgeon avoids most dexterously the chief difficulties of wrist-joint excision.

Before the operation is commenced, any adhesions of the tendons are thoroughly broken down by freely moving all the articulations of the hand. The radial incision is then made in the situation indicated by the thick line (L L) in Fig. 3283. This incision is planned so as to avoid the radial artery, and also the tendons of the extensor secundi internodii pollicis and indicator. It commences above, at the middle of the dorsal aspect of the radius, on a level with the styloid process, this being as close to the angle where the tendons meet as it is safe to go. Thence it is at first directed toward the inner side of the metacarpo-phalangeal articulation of the thumb, running parallel in this course to the extensor secundi internodii; but on reaching the line of the radial border of the second metacarpal bone, it is carried downward longitudinally for half the length of the bone. The soft parts at the radial side of the incision are next detached from the bones with the knife guided by the thumb-nail, so as to divide the tendon of the extensor carpi radialis longior at its insertion into the base of the second metacarpal bone, and raise it, along with that of the extensor carpi radialis brevior previously cut across, and the extensor secundi internodii, while the radial artery is thrust somewhat outward. This prepares the way for the next step, which is the separation of the trapezium from the rest of the carpus, by means of cutting forceps applied in a line with the longitudinal part of the incision—a procedure which, as experience shows, does not endanger the radial artery. The removal of the trapezium is reserved till the rest of the carpus has been taken away, when it can be dissected out without any considerable difficulty; whereas its intimate relations with the radial artery and its secure connections with the neighboring parts, would cause a great deal of trouble at an earlier stage of the operation. The soft parts on the ulnar side of the incision are now dissected up from the carpus as far as is convenient, the hand being bent back to relax the extensor tendons of the fingers. The separation of these is, however, best effected from the ulnar incision, which must be made very free. The knife is entered at least two inches above the end of the ulna, immediately anterior to the bone, and is carried downward between it and the flexor carpi ulnaris, and on in a straight line as far as to the middle of the fifth metacarpal bone at its palmar aspect. (Fig. 3284.) The dorsal lip of this inci-

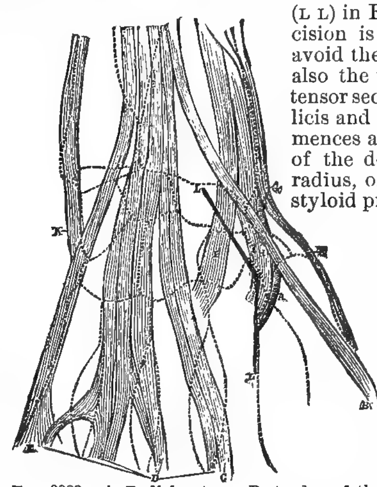


FIG. 3283.—A, Radial artery; B, tendon of the extensor secundi internodii pollicis; C, indicator; D, extensor communis digitorum; E, extensor minimi digiti; F, extensor primi internodii pollicis; G, extensor ossis metacarpi pollicis; H, extensor carpi radialis longior; I, extensor carpi radialis brevior; K, extensor carpi ulnaris; L L, line of the radial incision.

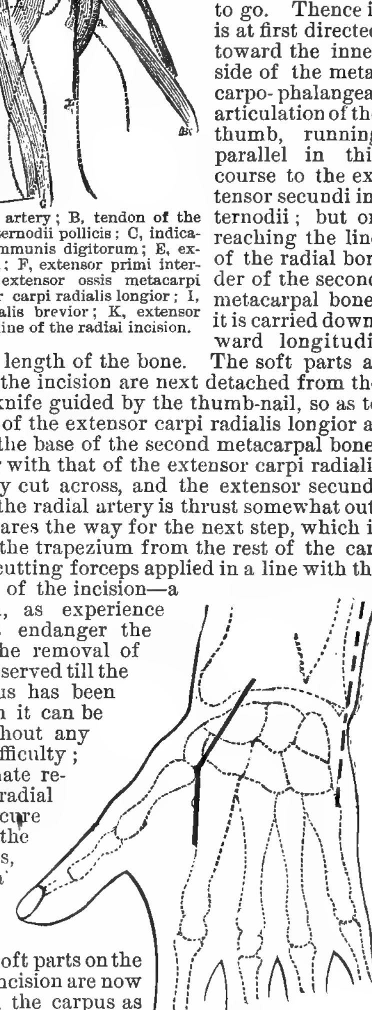


FIG. 3284.

* Gangolphe, De la Résection du Poignet, Revue de Chirurgie, 1884, p. 340, relates among others three successful cases at the ages of forty-six, fifty, and sixty-six years; one of whom was operated on after having refused amputation. Other cases of success, in spite of forbidding complications, are detailed.

sion is then raised, and the tendon of the extensor carpi ulnaris is cut at its insertion into the fifth metacarpal bone, and is dissected up from its groove in the ulna, care being taken to avoid isolating it from the integuments, which would endanger its vitality. The extensors of the fingers are then readily separated from the carpus, and the dorsal and internal lateral ligaments of the wrist-joint are divided; but the connections of the tendons with the radius are purposely left undisturbed. Attention is now directed to the palmar side of the incision. The anterior surface of the ulna is cleared by cutting toward the bone so as to avoid the artery and nerve; the articulation of the pisiform bone is opened, if that has not been already done in making the incision, and the flexor tendons are separated from the carpus, the hand being depressed to relax them. While this is being done, the knife is arrested by the process of the unciform bone, which is clipped through at its base with pliers. Care is taken to avoid carrying the knife further down the hand than the bases of the metacarpal bones; for this, besides inflicting unnecessary injury, would involve risk of cutting the deep palmar arch, the position of which is shown in Fig. 3285. The anterior ligament of the wrist-joint is also divided, after which the junction between the carpus and the metacarpus is severed with cutting pliers, and the carpus is extracted by seizing it from the ulnar incision with a serviceable pair of sequestrum forceps, and touching with the knife any ligamentous connections that may remain undivided. The hand being now forcibly everted, the articular ends of the radius and ulna will protrude at the ulnar incision, and are carefully examined and treated according to their condition. If they appear sound or very superficially affected, the articular surfaces only are removed. The ulna is divided obliquely with a small saw, so as to take away the cartilage-covered rounded part over which the radius sweeps, while the base of the styloid process is retained. The end of the radius is then cleared sufficiently to permit a thin slice to be sawn off parallel to the general direction of the inferior articular surface. For this purpose it is scarcely needful to disturb the tendons in their grooves on the back of the bone, the bevelled ungrooved part being enough to remove, and thus the extensor secundi internodii pollicis may never appear at all. The articular facet on the ulnar side of the bone is then clipped away with bone forceps applied longitudinally. If, on the other hand, the bones prove to be deeply carious, the pliers or gouge must be used with the greatest freedom. The metacarpal bones of the fingers are next dealt with on the same principle. If they seem sound, the articular surfaces only are clipped off, the little facets by which they articulate with one another being removed by the longitudinal application of the pliers.

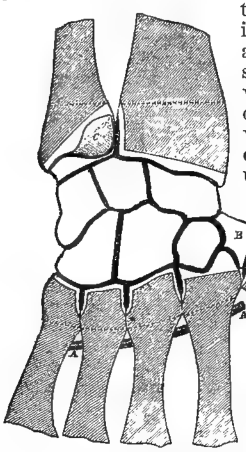


FIG. 3285.—A A, Deep palmar arch; B, trapezium; C, articular surface of the ulna, over which the radius moves.

The trapezium is next seized with a strong efficient pair of forceps, and dissected out so as to avoid cutting the tendon of the flexor carpi radialis, which is firmly bound into the groove on its palmar aspect, the knife being also kept close to the bone elsewhere to preserve the radial artery. The thumb being then pushed up longitudinally by an assistant, the articular end of its metacarpal bone is cleared and removed. Lastly, the articular surface of the pisiform bone is clipped off, the rest of the bone being left, if sound, as it gives insertion to the flexor carpi ulnaris, and affords attachment to the anterior annular ligament, and may serve other useful purposes in the palm. But if there is any suspicion of its unsoundness, it must be dissected out completely. The same applies to the process of the unciform. It may be observed that the extensors of the carpus are the only tendons divided; for the flexor carpi radialis is connected with the second metacarpal bone below its base, and so escapes.

The long single dorsal incision seems to have been used independently by several operators, but its use was made general through the influence of Langenbeck, and generally bears his name. His method is as follows: [30]

The hand is back upward and slightly bent toward the inner side. The cutaneous incision, beginning at the centre of the ulnar border of the metacarpal bone of the index-finger, is carried upward about four inches (nine centimetres), to the middle of the dorsal surface of the radial epiphysis (Fig. 3286). The incision is carried deeply on the radial side of the extensor indicis and without injuring its sheath, passing upward to the ulnar border of the extensor carpi radialis brevior (just at its insertion into the base of the third metacarpal bone). Here it divides the posterior annular ligament between the tendons of the extensor secundi internodii pollicis and the extensor indicis as far as the epiphyseal border of the radius. The incision being carried down to the bone, the soft parts, including the fibrous sheaths of the tendons, are lifted with the elevator and knife, together with the periosteum, the sheaths being unopened, first to the radial and then to the ulnar side of the incision. The hand is flexed so that the articular surfaces of the upper row of carpal bones are exposed. The scaphoid is liberated from the trapezium and trapezoid, and the semi-lunar and cuneiform from the os magnum and unciform by dividing the intercarpal ligaments, and gently lifted out with a narrow elevator. The trapezium and pisiform can be left behind [if sound]. The bones of the anterior carpal row are then taken out, the globular articular head of the os magnum is seized with the fingers of the left hand or a pair of vulsellum forceps, and while an assistant abducts the thumb the ligaments uniting the trapezium with the trapezoid are divided. The operator then tries to penetrate from here in a direction toward the ulna, into the carpo-metacarpal joints, by dividing the ligaments on the extensor side of the bases of the metacarpal bones, while an assistant forcibly flexes the latter. The trapezoid, magnum, and unciform can thus be lifted out together. The ends of the radius and ulna are carefully denuded, protruded, and sawn through in the usual manner.

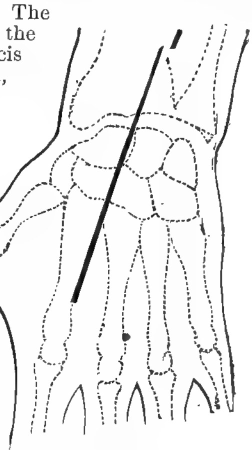


FIG. 3286.

Ollier urges the subperiosteal method. Although admitting that the wrist is not so good a field for this method as some other joints, he believes that the establishment of the "periosteo-capsular sheath" is useful in the repair. It hinders the changing of the relations of parts, and helps the forming of osseous or fibro-osseous masses which, although smaller than normal, are of value. They are irregular, and are bony grains "disseminated in an osseous gangue" which make the wrist firm but flexible. In one of his later articles,[31] Ollier claims that his opinion is based on the results of twenty-two personal cases of radio-carpal resection for osteo-arthritis, not counting partial ablations of the carpus and articular cauterizations in children. In addition he has had two primitive traumatic resections. After all the doubt arises whether the results, which in some cases were remarkably good, were due as much to the method of operation as to the very patient and pains-taking after-treatment.

The incision he formerly advocated [32] was on the radial side (see Fig. 3287). More recently [33] he has employed an incision much like that of Langenbeck, as follows :

The guides are an imaginary line connecting the styloid processes, the tendon of the extensor indicis, if recognizable, and the head of the second metacarpal bone. The patient lies upon his back, the hand extended and prone. An incision four or five inches long, commencing above the head of the second metacarpal, is made on the radial side of the tendon of the extensor indicis, and follows its direction until the bi-styloid line is reached near its middle. The cut divides the skin and subcutaneous tissue, a branch of the radial being drawn aside and the veins cut between two ligatures. Over the wrist the cut goes down to the periosteum and dorsal ligament, between the tendon of the extensor indicis and that of the extensor carpi radialis brevior. The annular ligament is divided and the tendons drawn widely apart. The articulation being open, all attachments on the dorsal surface of the carpus are separated by the sharp periosteotome (détachetendon), the carpus is dislocated backward by a movement of forced flexion, and the denudation of bone is continued on the palmar side until one of the bones can be extracted. Then, by the aid of the forceps and the periosteotome, the bones, one after another, are denuded and removed. The articular surfaces of the bones of the forearm are then examined, and if they must be resected, the incision is continued upward in the axis of the forearm, and making a slight angle with the first part. This incision reaches the bone between the tendons of the extensor proprius pollicis and the extensor indicis. The bones are denuded first toward the radial side as far as possible, the head of the ulna next, the bones dislocated and sawn.

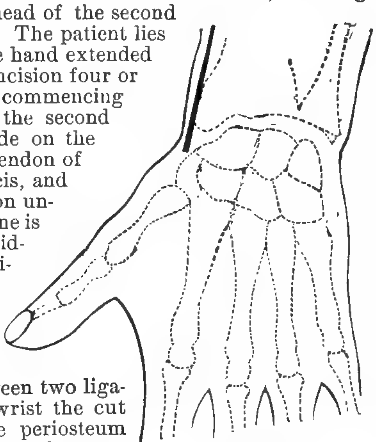


FIG. 3287.

After-treatment demands especially free and complete drainage of the wound. The palmar surface of the hand and forearm should be supported by a splint, the hand in dorsal flexion. Fig. 3288 shows Lister's splint. Plaster of Paris, or any other splint material, may be used if the points are kept in mind that the wrist shall be in dorsal flexion and the splint allow of early manipulation of the fingers. Early and persistent passive motion of the fingers is absolutely essential to success ; and faradism of the muscles of hand and forearm is of great service. Prolonged and painstaking care alone secures the best results.

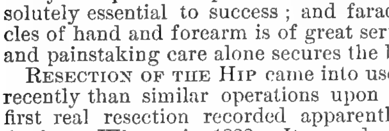


FIG. 3288.

RESECTION OF THE HIP came into use somewhat more recently than similar operations upon other joints, the first real resection recorded apparently being that of Anthony Whyte, in 1822. It was done for deformity, and the patient made a good recovery. The first operation for gunshot injury was done by Oppenheim, in 1829, during the Russo-Turkish campaign. The patient died of an intercurrent disease, plague or typhus. Resection for caries was performed by Brodie, in 1836, and perhaps by Hewson, of Dublin, in 1828, although the precise occasion of this operation is variously stated. Ferguson's operations, beginning in 1845, and those of some of his contemporaries, recalled professional attention to resection of the hip, and it thenceforward grew in favor until it took its place as an established procedure.

The discussion as to the value of resection has nowhere been warmer than in regard to the hip-joint, at least when done for disease. The matter will again be referred to under the head of Indications.

Strictly speaking, resection of the hip is "complete" only when the acetabulum is more or less involved in the operation, as well as the head of the femur. In this sense "partial" operations are commoner than "complete," and the mortality for the latter is somewhat higher than for the former, owing, doubtless, to the greater gravity of cases which demand interference with the acetabulum, rather than to the greater severity of the operative procedure.

Resection of the hip is done for gunshot wound, for caries, and, less frequently, deformity resulting from disease or injury. It has also been done for ancient dislocations of the hip, traumatic [34] or spontaneous,[35] for recent luxation with fracture of the neck,[36] for intracapsular fracture,[37] for congenital luxation of the hip,[38] for acute suppuration of the hip, and even for acute infectious osteomyelitis.[39] In a case of the last mentioned kind the writer once excised simply as a palliative measure to relieve suffering.

Results.—The mortality of resections of the hip for gunshot wounds has always been very high. Culbertson's tables make it 89.07 per cent., Gurlt's tables, 88.23; for cases in military practice only, 89.92 per cent. There is a singular agreement in the results in various wars, as, for instance, our own war gives 90.90 per cent., while the German war gives 90.56 per cent. Gurlt gives the following as the results of resections at different periods : Primary, 92.68 per cent. ; intermediary, 94.11 per cent.; secondary, 89.39 per cent. ; late, 60 per cent. These figures of mortality may be compared with those of amputation at the hip-joint and conservative treatment. Thus Otis states "that of the cases of undoubted intracapsular shot-fracture of the hip treated by conservation, 98.8 per cent. had a fatal termination ; that in 66 cases treated by excision the fatality was 90.9 per cent., and that in 66 cases treated by exarticulation it was 83.3 per cent. The high death-rate of resection, however, was modified by the fact that the operation was done in nine cases where the injury to the pelvis and viscera was found to be such that all interference was uselesss, and the numerical comparison, therefore, is not a just one. Further, of six cases of resection of the hip in the United States service since 1865, and reported by Otis, four recovered. Of the six recovered cases belonging to the War of the Rebellion, two could walk with a cane, one without support. In the other cases the limb was of little value. The results since 1865 were better. Gurlt gives for recovered cases "very good," 25 per cent.; "good," 75 per cent.

The mortality of resection of the hip, when done for disease, is very low, if death from the immediate results of the operation are considered. Culbertson's tables contain 418 cases, with 174 deaths, or 41.62 per cent. ; or, omitting uncertain cases, 44.84 per cent. Only 29 deaths, or 6.93 per cent., resulted directly from the operation, leaving 37.91 per cent. as the result of the progress of the disease or its complications. The most extensive statistics of antiseptic operations are those of Grosch,[40] who gathered 166 cases, 120 observed to the end, the mortality being 36.7 per cent. It will be noted that asepsis has practically annulled the mortality from operation. Grosch's results correspond closely with those of Culbertson, if operative deaths are left out.* The results of Grosch, König, Caumont, and others show that the mortality of hip-disease from tubercular complications has not been diminished by antiseptic surgery. That the death-rate of excised cases is greater than that of all cases of suppurative hip-disease treated by expectancy or conservatively, is not an argument against resection in proper cases, as the operation is usually applied only to the graver cases.

* The matter of statistics and of indications will be found discussed more at length in the writer's article in N. Y. Med. Journal, November 28, 1885.

Functionally, the results of resection for hip-disease cannot, statistically, be presented. Many cases have recovered with admirable limbs, mobile and stable. See, for example, Fig. 3289, from Sayre. But such cases are relatively rare. Many never really are healed, and many others are healed with limited motion, or without any. The precise percentage of each class cannot be given except for very small groups of cases. Hence the question has been debated, and, perhaps, as ably as by anyone, by Holmes,[41] whether the results of excision are, on the whole, as good as those of cures by anchylosis. To the writer it seems clear that the results of excision are not, on the average, as good as anchylosis in a good position. For the function of the lower extremity is support as well as locomotion. Security in the support of the trunk is, in most occupations, more important than mobility at any one joint. But this fact does not touch those cases in which a "natural" cure cannot be reasonably looked for. It is an argument only against precipitate and indiscriminate excision.

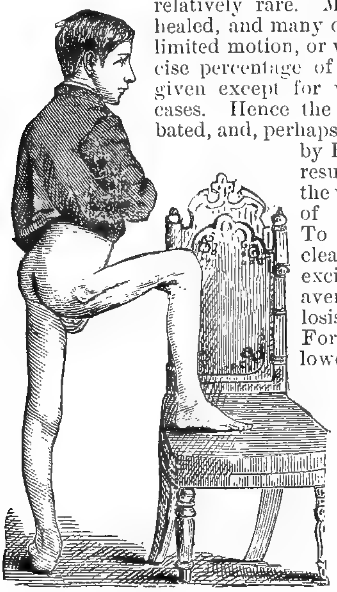


FIG. 3289.

Indications.—In military surgery Otis holds that primary excisions of the head or upper extremity of the femur should be performed in all uncomplicated cases of shot-fracture of the head and neck, that intermediary excisions are indicated in similar cases where the diagnosis is not made out till late, and that secondary excisions are demanded by caries of the head of the femur, or secondary involvement of the joint. These indications are influenced by the very high mortality attending conservative treatment. Langenbeck[42] finds the experience in conservatism during the Franco-German war to have been less dismal; he reports 25 recoveries against 63 deaths, and in nearly all of the recovered cases the diagnosis may be considered well founded. In view of the remarkable change in the prognosis of such injuries in civil practice, where antiseptic methods are used, it is impossible to accept the gloomy view of Otis as final; and where asepsis is possible in the field, it seems entirely proper to treat conservatively uncomplicated cases of shot-injury of the hip where little comminution exists, and the general condition of the patient is good. But in the majority of cases the rule for resection holds good.

For caries resection is indicated under the general rule, namely, whenever conservative treatment has failed or cannot succeed. As it has not been shown that, on the average, resection gives limbs more useful than natural cure, even after joint-suppuration, nor that, counting the period of after-treatment necessary to the securing of a good result, it materially shortens the duration of treatment, the indication remains entirely a vital one. If conservative treatment probably cannot save life or effect cure, operative procedures are indicated. More specifically, if a sequestrum or necrosis of the acetabulum or of the head or neck of the femur exists, resection is imperative; if pelvic abscess or advanced disease of the acetabulum is present, resection is the only alternative, even if only palliative; if, by reason of caries or inveterate disease of the soft articular tissues, suppuration persists and impairs the general condition in spite of treatment, resection is called for. It may be called for in the rather rare cases of caries with little suppuration and great suffering, the so-called caries sicca, to relieve pain. Early resection, with the intent to arrest coxalgia before conservative treatment has been fairly tried, cannot be considered as a necessary or advisable operation.

In acute suppuration of the hip, arthrotomy with drainage may obviate the necessity of resection, but an incision suitable to either operation should be made, and the decision left until after exploration.

Resection may be done for deformity when the latter is due either to bony or fibrous anchylosis, or to displacement of the upper extremity of the femur upon the dorsum ilii, with perhaps persistent sinuses. The operations for deformity have included not only resection of the hip joint or its remains, but of the upper part of the shaft of the femur as well as simple osteotomy of the femur. These all, however, are here included, as they are all used as means of rectifying the deformity resulting from hip-disease. Resections for dislocations not connected with hip-disease have been alluded to above. Operative interference for deformity is called for when the position of the limb is such as to make locomotion difficult, and when there is a reasonable prospect of improvement by operation; when, especially in women, the position of the limb makes cleanliness difficult, and causes much annoyance in connection with micturition, menstruation, etc.; also when the false position is attended with pain.

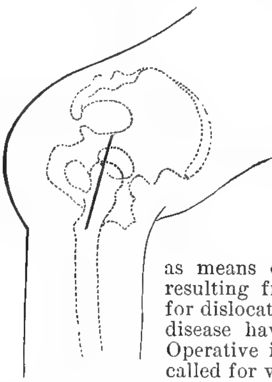


FIG. 3290.

Methods.—Owing to the relative simplicity of the hip-joint, its excision is not difficult. In the majority of operations incisions over or behind the great trochanter have been employed. The three best known are Langenbeck's, Sayre's, and Ollier's. They are all subperiosteal. The first (Fig. 3290) is made when the thigh is semi-flexed, by carrying the knife from the middle of the trochanter upward and backward in the line of the axis of the thigh, four or five inches toward the posterior superior spine of the ilium. The incision separates the fibres of the gluteus maximus, and divides the fascia lata and periosteum of the trochanter. The muscles inserted into the trochanter, front and back, are freed with the knife, their connection with the periosteum and fascia lata being preserved as far as possible. The capsule is then completely divided by strokes of the knife in the axis of the neck of the femur. The periosteum, with the capsular ligament and the insertion of the obturator externus, is separated all around the neck of the femur. The cartilaginous rim is divided, and a piece removed with the knife on both sides of the incision. The limb is adducted and inverted, dislocating the head of the femur; a narrow knife is thrust into the joint from behind, and the ligamentum teres divided. The head is protruded and sawn off. The trochanter is left if sound. The acetabulum is drained and the wound closed.

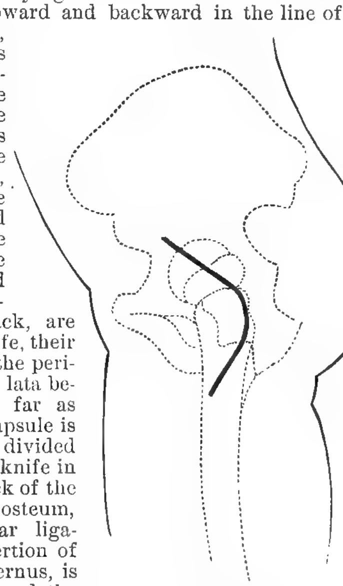


FIG. 3291.

Sayre's procedure probably is that most frequently em-

ployed in this country. It is as follows: A strong knife is thrust down to the bone at a point midway between the anterior inferior spinous process of the ilium and the top of the great trochanter. The knife, still firmly in contact with the bone, is carried in a curved line over the ilium across the top of the trochanter, midway between its centre and its posterior border, and then forward and inward, making the whole length of the incision from four to eight inches, according to the size of the thigh (Fig. 3291). This incision should divide the periosteum throughout; if it has not done so, the point of the knife must traverse the same course again until the division is complete. The wound is then held open with retractors, and with a narrow, thick knife a second incision is made through the periosteum only, at right angles to the first incision, about on the level of the lesser trochanter, or a little above it, and carried as far as possible around the bone behind and before. This makes the incision through the periosteum an inverted **T**. Beginning at the angles of the two incisions, the periosteum is raised with the elevator (Fig. 3248), before and behind. In the digital fossa the knife must be used to divide the muscular insertions, its edge being kept close to the bone. The elevator is then resumed, and the periosteum raised as far as can be done without breaking it. The limb is then slightly adducted, and the head of the femur lifted out from the acetabulum. This manœuvre detaches the periosteum from the inner side of the bone, and should be done without violence, and care should be taken to denude only so much bone as is to be sawn off. If this dislocation cannot be easily accomplished, saw the bone *in situ*, and detach the fragment by means of the forceps and elevator. The bone is removed by the keyhole- or chain-saw, the line of section being just above the trochanter minor. Dr. Sayre always removes the trochanter major, as he holds that its retention prevents free drainage of the wound. When the operation is made in childhood, the larger part of the trochanter is still cartilaginous, and is turned off with the periosteum from the diaphysis. If the disease extends below the line of section, the bone should be thrust out from its periosteum and again sawn. The acetabulum is then examined; if diseased, gouged or scraped; if perforated, all bone from which the internal periosteum is detached should be removed. The sinuses are cleansed.

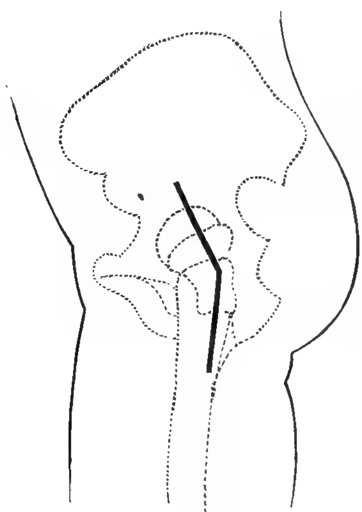


FIG. 3292.

Ollier's incision is made thus [43] (Fig. 3292): The thigh being slightly flexed on the pelvis, say to 135 degrees, the incision begins four finger-widths below the crest of the ilium and the same distance behind the anterior superior spine. It runs down and slightly forward in the direction of the fibres of the gluteus medius, to the prominent part of the great trochanter. It then changes its direction and goes forward and downward in the axis of the shaft of the femur. The posterior lip of the wound is drawn back, the tendon of the gluteus maximus crowded back with the elevator, and the gluteus medius exposed. This muscle is divided parallel to its fibres, dividing, not cutting, them. The gluteus minimus is treated in the same manner, and the capsule opened from the cotyloid border to the digital fossa of the trochanter. The muscular insertions are not separated from the periosteum. The head is pushed up, the round ligament cut, and the neck of the bone denuded as it is pushed up; when it is sufficiently exposed and protruded it is sawn off.

Ollier also makes use of an osteoplastic method.[44] The incision is curved convex downward, the centre being the lowest part, a fourth of an inch below the top of the trochanter, and the ends about an inch and a half (in an adult) before and behind the corresponding borders of the trochanter. The trochanter is exposed, sawn, or in childhood cut with a strong knife, at an angle of 45 degrees with the shaft, and the piece broken off and turned up; the head and neck are then denuded and removed, and the trochanter replaced and sutured to the shaft if none of the latter has been removed.

Langenbeck's operation seems to have been founded upon the requirements of an operation made for gunshot injury, while those of Sayre and Ollier are particularly applicable to operations for disease.

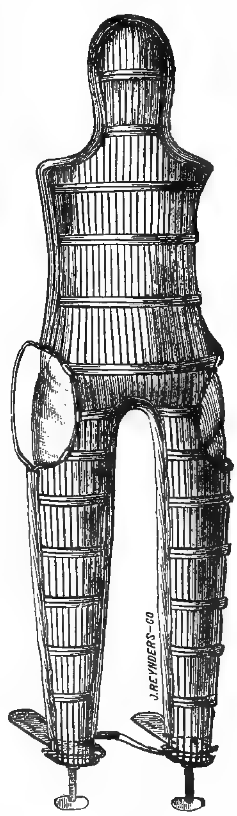


FIG. 3293.

Besides these methods many others have been proposed and employed. Thus Roser [45] recommends, in order to save the trochanter, a transverse incision from the outer side of the crural nerve to the root of the great trochanter. Lucke[46] and Shede[47] make a longitudinal anterior incision to the outer side of the crural nerve. R. W. Parker [48] makes an antero-lateral incision running from the anterior superior spine of the ilium downward and forward to the anterior border of the great trochanter. It enters between the tensor vaginæ femoris and sartorius on the inner side, and the two smaller glutei muscles on the outer, exposing the capsule. If this is not already open it is incised with a blunt-pointed curved bistoury, parallel to and rather inside of the anterior inter-trochanteric line. The neck of the bone is sawn *in situ* with a keyhole-saw and removed with the sequestrum forceps. The trochanter is left if not diseased. These anterior incisions seem to present little of advantage over the older ones, although, if suppuration is overcome by aseptic precautions, they may be safe. If, however, much suppuration occurs, they have the decided disadvantage of poor drainage. If sinuses already exist in the locality these incisions may occasionally be found useful.

Dr. Sayre dresses the wound by washing it out, filling it with Peruvian balsam, and stuffing it with oakum, the ends only of the wound being closed with stitches, and a tent of oakum in the middle serving for drainage. A layer of oakum is laid over the wound, and the limb neatly bandaged. He prefers to place the patient in the wire cuirass (Fig. 3293), which is previously well padded, and is fitted with extension screws at the feet. When a patient is firmly fixed in this apparatus, he can be moved with great ease without discomfort, and for very young and not very tractable patients it is a great convenience. Ordinarily, however, the usual antiseptic toilet of the wound may be used, and a firm antiseptic dressing with weight and pulley extension, make a very comfortable and satisfactory appliance. Fig. 3294 shows a good method of applying the antiseptic dressing.

When the wound is considerably consolidated, the question of passive motion is to be considered. If mo-

bility of the new articulation can be had in conjunction with stability it is very desirable, but if but one can be had, in nearly every walk in life stability is much the more

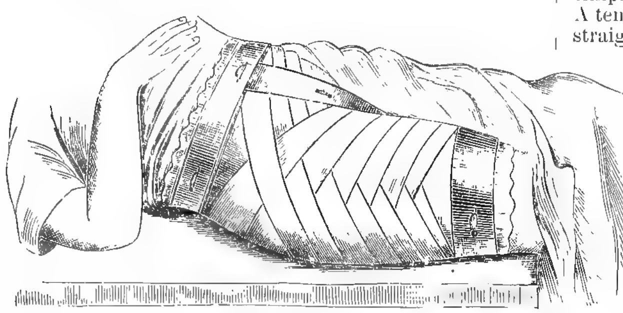


FIG. 3294.

desirable. It has been urged, therefore, by some observers of experience, that anchylosis after resection of the hip should be directly aimed at. If there is much destruction or necessary removal of bone this is probably the wisest plan but if the case gives hope of both, then passive motion may be begun after the parts are already moderately firm. For a considerable time, many months at least, the wearing of a support, such as the hip-splint (Fig. 3295), is of decided advantage in securing firmness of the forming new articulation.

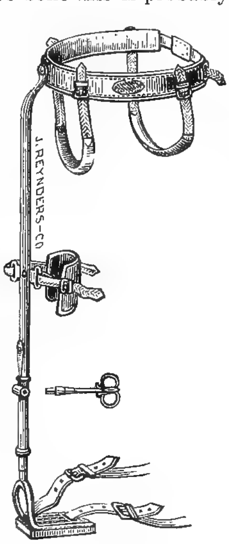


FIG. 3295.

Operations for Anchylosis.—Rhea Barton, in 1826, operated by resecting a **V** from the shaft of the femur, with a good result. Similar operations followed.

Sayre, in 1862, operated upon two patients for bony anchylosis of the hip.[49] The operation was essentially the same in both cases, and in the second case was as follows: An incision six inches long was made over the trochanter, as nearly as possible crossing its centre and going directly down to the bone. About the centre of this incision another at right angles was made, in the posterior flap, carried only through the broad fascia. The bone was then denuded with the elevator, first in front to the trochanter minor, and then behind till the finger could surround the bone, with the exception of a thin, firm fascia between them on the front. This was pierced by a bent steel sound, and a chain-saw carried around above the trochanter minor, which served as a guide. About half an inch above the trochanter minor the saw was carried through the bone, at first upward and outward, then outward, then downward and outward, making a curved section concave downward. The saw was again carried around the bone, and commencing about an eighth of an inch before the beginning of the first section, a second section was made at right angles to the axis of the shaft of the bone (see Fig. 3296). The wound was drained and closed. Extension by weight and pulley.

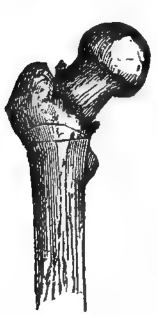


FIG. 3296.

In the first case the result was very satisfactory functionally. The second patient did well, and gained considerable use of the limb. About four months afterward was attacked with pneumonia and died tuberculous about six weeks later. A very good false joint had formed in this case.

Adams,[50] in 1869, operated for anchylosis by the much simpler method of osteotomy of the neck of the femur. A tenotomy knife was carried straight down from a little above the top of the great trochanter to the neck. A small saw (Fig. 3297) was inserted into the same track and the bone sawed through from before backward (Fig. 3298). Tenotomy of several muscles was necessary before the limb was brought into a straight position. Wound closed. Liston's splint. Anchylosis occurred in the improved position, but the limb was very useful. In some cases since operated upon motion has been preserved, at least for a time. Fig. 3299 shows Dr. Shrady's very convenient instrument for making this and similar operations. It consists of a trocar and fenestrated cannula, and a saw fitting the same cannula. In use the trocar is thrust to the point which is to be sawed. The trocar is then withdrawn, the cannula being left in position, the screw-button on top, on the side opposite to the fenestra, being a guide to the position of the latter. The saw is then introduced through the cannula, and the section made without danger of wounding any parts except those intentionally divided.

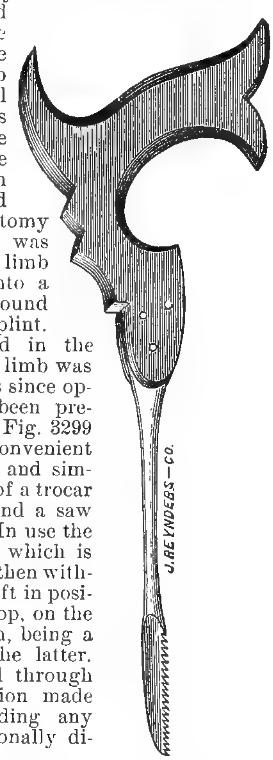


FIG. 3297.

Volkmann, who formerly advocated sub-trochanteric osteotomy to correct deformity, has devised[51] a "chisel resection" for anchylosis at the hip. The incision is Langenbeck's (see ante). The great trochanter is cut nearly through about an inch below its summit, and the inner wall of the neck of the femur broken through. The inner side of the end of the shaft is rounded with chisel and rongeur until it is about as thick as the middle of the shaft. It is better to remove too much than too little. An acetabulum is then worked out with the gouge large enough to permit free motion of the new head. Antiseptic dressing. Strong extension by weight very long continued, and very persistent passive motion. For most cases Volkmann still prefers osteotomy, especially if the limb be short and atrophic. He considers the chisel resection indicated (1) when the anchylosis is double; one side should have an osteotomy for security, and one resection for locomotion; * (2) when it is not absolutely certain that the disease has been suppressed; (3) in great displacement of head of femur make osteotomy, and resect if necessary to bring bony surfaces together.

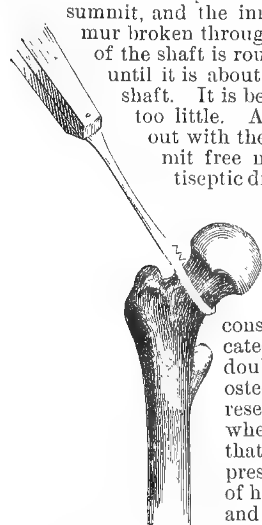


FIG. 3298.

RESECTION OF THE KNEE has an especial historical interest in that upon this joint the operation was first done for disease by Filkin (1762), and again, apparently independently, by Park (1781), who

* This suggestion has been carried out (Mordhurst, Archiv f. Kl. Chirurgie, xxxi., 677).

first in modern times proposed the operation of resection as a formal method of treatment of diseased joints instead of, as previously it had been, an extemporaneous means of meeting emergencies, such as compound dislocations. In spite of the distinct advocacy of Park and the Moreaus, the operation was slow in gaining ground, and previous to 1850 the recorded operations were few, Culbertson giving but 54 out of a total of 745 in his tables. The revival of the operation was due chiefly to the endeavors of Textor in Germany, and Fergusson in England.

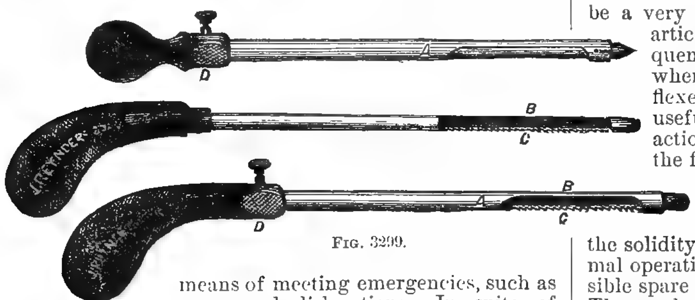


FIG. 3299.

In order that a resection of the knee may be considered *complete*, the articular surfaces of both femur and tibia must be removed; if one of these surfaces be left, however extensive the operation in other respects, it is still *partial*. The removal of the patella is not considered necessary to make the resection complete. As of other joints, resection of the knee is done for gunshot wound and other injuries, for disease, and for deformity.

Results.—The results of resection of the knee for gunshot injury have been discouraging, owing to the high mortality. Culbertson's tables show a death-rate of 75 per cent., or for hospital cases alone, 87.5 per cent. Otis gives for the War of the Rebellion a mortality of 81.4 per cent., which is much higher than the mortality of amputations at the knee-joint—56.6 per cent.—or for thigh-amputations for knee-injury—50.9 per cent. The same authority,[52] collecting cases from all sources, gives the mortality after conservative treatment as 57.3 per cent. when there was fracture of the joint-bones, and 21.9 per cent. when the wound did not involve the bone. Culbertson also gives the mortality of resection done for injury other than gunshot at 39.28 per cent., for disease at 25.32, for deformity at 13.2. A. M. Phelps[53] has tabulated 329 cases of antiseptic excision of the knee with 31 deaths, or 9.42 per cent., or (deducting 15 cases of phthisis, 1 ether death, 2 amyloid disease, 2 nephritis, 1 poisoned wound) 10 deaths properly due to operation, or 3.03 per cent. Likewise Bergmann reports excellent results for wounds of the knee-joint under antiseptic dressing (of wounds not involving bone out of 21 cases 18 recovered; 3 under treatment).

Culbertson shows that age influences mortality. The mortality of operations for disease under five years of age was 38.88 per cent.; from five to ten years, 16.19 per cent.; from ten to fifteen years, 17.17 per cent.; fifteen to twenty, 30.11 per cent.; twenty to twenty-five, 39.39 per cent.; twenty-five to thirty, 37.3 per cent.; thirty to forty, 41.55 per cent.

As to function, after recovery from resection for gunshot wound, 58.8 per cent. of limbs were reported "useful;" 23.8 per cent. were subsequently amputated (Culbertson). According to Gurlt (German wars from 1848 to 1871), 55.55 per cent. of limbs were "very good;" 33.33 per cent. "good;" 11.11 per cent. "very bad." "Perfect" or "good" results followed operations for injury in 82.3 per cent. of cases; for deformity in 87.3 per cent., and for disease in 56.7 per cent.

The functional failures are due in some cases to the destruction of the epiphysial cartilages. As is well known, the femur grows chiefly from its lower epiphysis, and the tibia from its upper one. If in childhood one or both of the epiphyses are totally removed the shortening of the limb may be excessive. Other failures arise from non-union or imperfect union of the sawed surfaces. Usually in resection of the knee anchylosis is aimed at. It is now known that without bony union, or even with considerable motion at the false articulation, the limb may be a very useful one; but great stability of the new articulation is necessary to good use. It not infrequently happens, and particularly in children, that when the limb is walked upon it gradually becomes flexed at the knee to such a degree as to destroy its usefulness. This flexion is due to the combined action of the weight of the body, the traction of the flexors of the legs, and, it is believed, by the greater growth of the anterior part of the epiphysis. The two forms of failure have led to various technical devices to increase the solidity of the union, on the one hand, and to informal operations, on the other, which should as far as possible spare sound tissue and preserve the joint functions. The results of informal operations cannot be statistically stated, but they seem, from reported evidence, worthy of trial in favorable cases, even if, as some claim, relapses demanding subsequent excision sometimes occur.

Indications.—Resection for gunshot injury in military practice has proved so fatal that unless aseptic surgery shall give better results it seems hardly to be indicated at all. Such improved results are still wanting. Gunshot wounds of the knee without fracture seem, in the light of the latest experience (Bergmann) to do well without operation if antiseptically treated. If fracture exists, amputation is still the safest alternative.

In fungous disease operative interference is indicated whenever such expectant treatment as the patient can command has failed to improve the condition, especially if there is a persistent suppuration, and in any case in which the functions of the joint seem to be hopelessly impaired, inasmuch as the anchylosis necessary to a useful limb can be much more quickly reached by antiseptic operation than by the tedious process of natural cure. Fungous disease presents peculiar features at the knee, notably in the relatively less extensive bone-lesions and the predominant fungous synovitis. The peculiar, sluggish course of "white swelling" renders interference proper without open suppuration or certain bone-disease. There is also a greater latitude of choice as to kind of operation than is usual at other joints; namely, between arthrotomy, arthrectomy, resection more or less complete, and amputation. Arthrotomy, so valuable in acute joint-inflammations, has not proved equally efficient in fungous disease. The distinction between arthrectomy and true resection is not a very hard-and-fast one, inasmuch as, besides the extirpation of the diseased soft tissues, all diseased bone is gouged away, and although the typical forms are departed from, the resection may be as extensive as in the most formal procedure. If by resection the formal operation alone is meant, it seems to be less frequently indicated than formerly was supposed. In very young children, under five years of age, it is not called for; in older children the informal operations will probably give at least as good results. Resection gives the best results, all things considered, in the age of adolescence, and next in early adult life. At this time of life the form of operative interference to be preferred is usually resection. The results become less satisfactory later on, and the choice between resection and amputation less clear; after middle life, most surgeons prefer amputation.

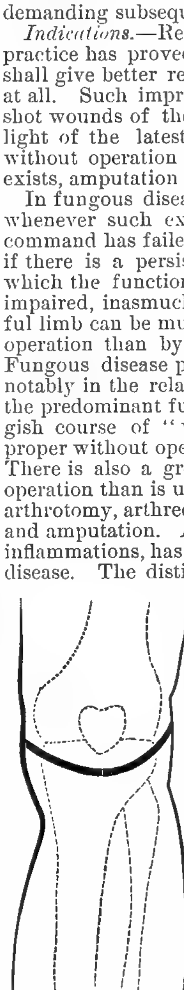


FIG. 3300.

Methods have been for this joint also very numerous. But the semilunar incision, convex downward, the **H**, and the transverse in its several varieties, are much the most frequently employed.

If in a typical resection the semilunar incision (Fig.

3300) is employed, the knife enters at the back part of one condyle and is carried somewhat downward, and crosses below the patella, and is carried to the back part of the other condyle. The point of the knife should be carried to the bone throughout its course, and divide the ligamentum patellæ. It may sometimes also divide the lateral ligaments. The flap is turned up, exposing the joint freely. The knife, kept close to the tibia, divides the crucial ligament, and section of the lateral ligaments is completed. The lower end of the femur is then cleared, especial care being used at the back of the bone to avoid wounding the vessels. The femur is now protruded and a thin slice, carrying the articular cartilage, is sawed off. Figs. 3301 and 3302 (from Holmes) show the relation of the ordinary saw-cuts to the epiphyseal cartilages. If it be possible to avoid it, these cartilages should not be touched; diseased parts only should be removed. The saw would better be carried not quite through the bone, but the last part broken away to prevent danger to the popliteal vessels and nerve, the rough edges of the bone being subsequently smoothed. In sawing the femur the cut should be parallel to the articular surface, and should remove an equal amount from both condyles. The tibia is cleared and sawed in the same manner. There is a decided variance of opinion about the removal of the patella, some operators preferring to keep it as an extra strength to the anchylosis, and as preventing the tendency to flexion which is quite common, especially in children; others preferring to take it away, as being of little use and a possible source of renewed disease. The writer shares the latter opinion, and believes that if in a typical resection the patella is to be left, its inner surface should be shaved off, so that a better judgment of the interior condition of the bone can be formed, and in order to insure its closer union to the other bones. The diseased synovial membrane is scraped or cut away, and all suspected parts of bone gouged.

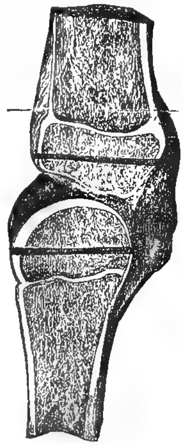


FIG. 3301.

If the transverse cut is used it may be just below the patella, and transverse to the axis of the tibia, in which case, as Ashhurst points out, if the knee is bent at the time of cutting, the incision becomes a semilunar one when the limb is straightened, and much like that already described. It may be made above the patella, giving convenient access to the upper pouch of the joint. Or, again, it may be made directly across the patella, at or slightly below its centre. If lateral offsets be added it becomes the **H**-incision, the upper and lower flaps being dissected and the remainder of the operation being as described for the semilunar incision. The incision across the patella was proposed by Volkmann, and has been considerably employed. It begins at the anterior border of one epicondyle and passes directly across the middle of the patella to the anterior margin of the other epicondyle. The joint is then opened on either side of the patella, the index-finger is thrust under the patella on either side for exploration, and if the operation is to proceed the bone is sawed across, the lower fragment turned down, and the joint cleared. The operation is to be finished as usual. This method facilitates extirpation of the joint. The section of the patella allows a judgment of the condition of that bone. If it is sound, it is left either entirely or with its inner surface shaved off. The fragments are then reunited by suture. Besides, Ollier recommends that for traumatic resections the patella be divided vertically in the course of a median longitudinal incision. Langenbeck made a subperiosteal resection through an internal semilunar incision, the convexity behind passing over the posterior part of the internal condyle. Ollier also urges the subperiosteal method, and formerly used the external anterior incision shown in Fig. 3303. He has more recently [54] recommended a small **H**-shaped incision, the lateral cuts converging below, together with lateral posterior drainage-openings made before the parts are removed. The patella is not retained, and section of the lateral ligaments is avoided if possible.

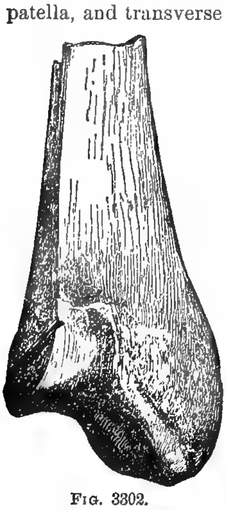


FIG. 3302.

Among modifications to secure greater fixation may be mentioned that of Neuber, who used the semilunar incision, and besides the usual resection of the articular surfaces trims off the posterior prominences of the condyles, shaves off the front of the tibia and femur, and the posterior surface of the patella. The femur and tibia being nailed together, the patella is nailed to their shaved surfaces so as to act like a clamp to hold the main bones in apposition. Fenwick [55] also uses the semilunar incision and follows the customary method until the bones are to be sawn. A fine fretwork saw, in a butcher's saw-frame, is then carried in a circular sweep over the condyles from before backward removing the cartilage and all diseased bone, both condyles being diminished equally, and the end of the femur is left rounded in an antero-posterior direction. The tibia is sawed from behind forward, with a concavity to fit the convexity of the femur. The patella is removed. Kocher [56] seems to employ nearly the same method.

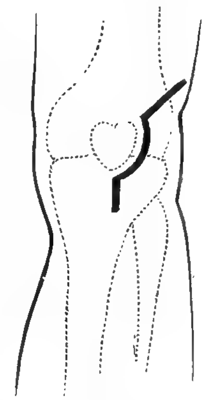


FIG. 3303.

A. M. Phelps urges resection of the hamstrings as a safeguard against subsequent flexion.

If arthrectomy is intended, it is well to choose an incision which will serve for resection if, after exploration of the joint, the latter operation seems to be preferable.

The operations for deformity are cuneiform osteotomy above the condyles (Rhea Barton); simple osteotomy of the femur, and of the femur and the leg bones (Barwell); removal of a wedge, including site of knee-joint (Buck), and breaking up of anchylosis followed by resection. If there is any doubt as to the persistence of disease at the joint, resection of the joint itself is the only operation. If the flexion is above a right angle, reduction of the deformity will probably demand the removal of a block of bone which is not a perfect wedge, *i.e.*, which has some thickness behind. The technique has nothing peculiar. Any convenient incision may be used, the **H** or the semilunar being usually most convenient. It is thought to be safer to break out the block or wedge before the entire thickness of the bone has been cut, and to finish with a chisel, gouge, or other convenient instrument.

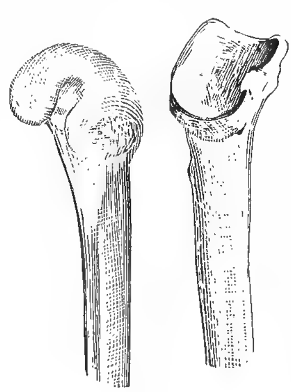


FIG. 3304.

It is usual to fasten the femur and tibia in apposition by sutures of wire or of catgut, or by nails or pins of bone. It is not necessary to use anything if the shape of the

sawn surfaces, as in Fenwick's method, for instance, is such as will, with the help of a firm dressing, maintain the juxtaposition. It is not absolutely necessary in the ordinary forms of operation,[57] but some such device is valuable to prevent the thigh from rotation outward, while the tibia remains in position, which results in a bad intoeing when the limb is otherwise fit for use. The methods of introducing wire and nails have been described. Additional firmness is gained by deep stitching of the soft parts.

The drainage should be from the posterior lateral angles of the wound, from the superior pouch, and other dependent points if necessary.

The antiseptic dressing is usually followed by a splint. Various devices have been satisfactorily employed, but for ordinary cases a good plaster bandage, fenestrated and bracketed, answers all purposes. A long anterior rod, shaped to the limb, bent at the knee into bracket-shape, and continued upon the dorsum of the foot, with

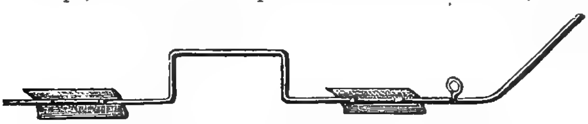


FIG. 3305.

rings for suspension (see Fig. 3305), as recommended by Watson, is an excellent addition to the plaster dressing. Suspension of the limb is usually comfortable, and prevents or diminishes the danger of displacement of the fragments if the patient changes his position. Subsequent dressings should be as infrequent as surgical cleanliness will allow, and the seat of operation be disturbed as little as possible.

The time requisite for union varies greatly, but is much shorter with antisepsis than without. Patients are confined to bed sometimes only a month, but usually a considerably longer time is required.

RESECTION OF THE ANKLE has suffered, in professional estimation, from essentially the causes that hindered the general acceptance of wrist resections. The number of bones, the complexity of synovial membranes, and the propinquity of many tendons, give many lurking places for disease, and often delay recovery, insure relapses, or destroy the functional value of the rescued foot. For these reasons many surgeons have preferred Syme's or Pirogoff's amputations. Better methods, however, have very much diminished this antagonism to resection. The results of limited operations are often excellent, and if extensive ones, sometimes leave a foot that is not much more than a stump, but it is, nevertheless, a much more useful stump than is usually obtained from amputation. Strictly speaking, resection of the ankle means removal of the articular surfaces of the tibia and astragalus, with or without the lower end of the fibula; usage, however, makes the phrase include more extensive invasion of the tarsus, at least as far as the mid-tarsal articulation. If both surfaces of the tibio-astragaloid articulation are removed, the resection is "complete." The operation was originally applied to the reduction of compound dislocations and fractures of the ankle, and, until about thirty years since, operations for injury considerably outnumber those for disease. Otis could find but three cases of resection for gunshot injury previous to 1861.

Results.—The death-rate from resection of the ankle for gunshot wounds in 45 cases, collected by Culbertson, was twenty-six per cent. Otis reports 33 cases from our own war, 7 only of which were technically complete, with a death-rate of twenty-nine per cent. He also collected 150 cases from other sources, nearly all more recent than our war, with a death-rate of 33.7 per cent. So far, therefore, the death-rate is higher than for ankle amputations, which in our war (Otis) was 25.1 per cent. The same authority concludes that the functional results are not very satisfactory, and prefers the "judicious use of the gouge and the bone-forceps" to formal exsections.

In civil practice the results for injury are better, the death-rate, according to Culbertson, for 152 cases being 12.5 per cent., and the functional results are better. Culbertson shows the death-rate for disease in 124 cases to have been but 8.06 per cent., which is not far from the mortality of Syme's operation done under similar circumstances. The death-rate of partial resections was but 6.55 per cent.

The operations made for injury usually result in anchylosis, and often with feet in faulty position, which greatly impairs their usefulness. Recurrence of disease in the tarsus is frequent when the operation has been done for caries. These reasons have led to the increased favor accorded to informal procedures.

Indications.—For gunshot injury, resection, in form, of the ankle-joint gives but indifferent results, and is in-

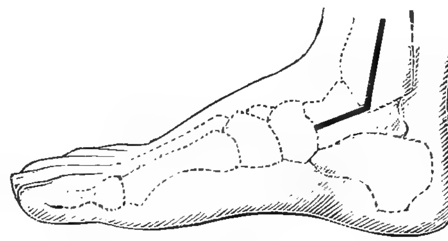


FIG. 3306.

dicated only under very favorable circumstances, and in cases which probably would do quite as well with informal removal of fragments and gouging.

Compound fractures or dislocations call for resection, generally partial or atypical, when the injury is attended with extensive damage to the soft parts, but not to nerves or vessels, or when the reduction of bones is difficult without the operation. Also, as a secondary operation, when suppuration has supervened upon a compound fracture and the tissues are already badly damaged, or cure is probable only through anchylosis, resection gives a speedier termination.

For caries, resection is rarely indicated in young children, and perhaps before puberty. In childhood, expectancy, with opening of abscesses, drainage, extraction of sequestra through sinuses, produces very satisfactory results. Even when, at this age, the caries is extensive, *évidement*, or its modification of scooping and setoning, as urged by Sayre, often saves the foot with nearly or quite perfect functions. After childhood, more formal operations come into question. The operation selected should be that involving the least mutilation of the soft parts consistent with complete extirpation of the disease. The retention of the malleoli, or of one only, gives a solidity to the parts which favors union in good position.

Methods.—The preference has been rather for lateral incisions, wholly or partly in the axis of the leg, as damaging the tendons less than transvere cuts. There have

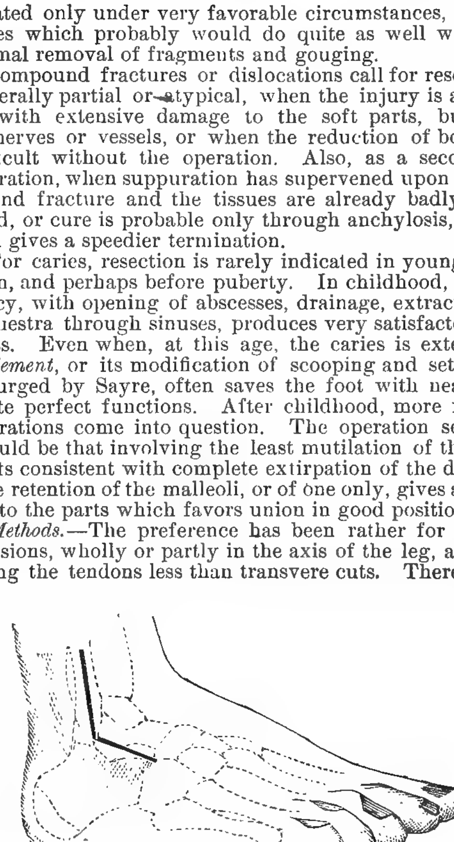


FIG. 3307.

been many varieties of this type. Figs. 3306 and 3307 show one of them, recommended by Wyeth,[58] which is made as follows: Commence an incision on the internal surface of

the tibia, about two inches above the tip of the inner malleolus, and carry it directly down to this point and thence forward from one inch to one inch and a half along the tarsus in the line of the metatarsal bone of the great toe (Fig. 3306). This incision extends a little anterior to the astragalo-scaphoid articulation. A light L-shaped incision is made upon the fibular side of the joint (Fig. 3307). With the Sayre periosteal elevator, lift from the diseased portions of bone the periosteum (with its attachments to the superjacent soft tissues undisturbed). Expose the outer malleolus and fibula as high as it is deemed necessary to remove this bone, and divide it with the exsector or chisel. As soon as the piece is removed, the joint is thoroughly exposed to view. Now, in the line of the tibial incision, further lift the periosteum of the tibia and tarsal bones, and, by forcibly bending the foot inward, dissect the tibia and inner malleolus outward through the wound on the fibular side. The diseased surfaces of the tibia and fibula may be sawn off with an ordinary saw, or with the exsector. The line of section should be at a right angle to the axis of the shafts of these bones, and should first remove the articular cartilage. Should the disease extend higher than this, an additional slice of bone may be removed, or any small sinuses thoroughly scraped out with Volkmann's spoon, and sponged out with sublimate, 1 to 1,000. The astragalus is now removed and the upper surface of the calcaneum sawn or chiselled off, so that a smooth and freshened surface is left. The cartilage should be scraped from the posterior articular face of the scaphoid. All of the soft tissues involved in the disease should be dissected away. The os calcis and tibia are now brought together, and if the sawn surfaces fit snugly with the foot at a right angle to the leg they are ready to be fastened. This is done by passing a nail or the Wyeth drill from the sole through the calcaneum up into the tibia. The drill is removed when sufficient firmness of the parts permits.

Langenbeck's subperiosteal operation also has bilateral incision. The external one consists of a cut about two and one-half inches long on the posterior border of the lower end of the fibula, and continues around the margin of the malleolus in a hook-shape. This is carried down to the bone, the fibula denuded without harm to the tendon of the peroneus longus. The fibula is divided at the upper level of the incision with the keyhole-saw, the fragment carefully separated from the interosseous ligament, which must be preserved on account of its influence on the reproduction of bone, and, finally, from its ligamentous attachments to the astragalus and calcaneum. If diseased, the articular surface of the astragalus is sawn off with a keyhole-saw from before backward. The internal incision is anchor-shaped, the curved part about an inch and one-half long, follows the lower border of the malleolus; the straight part, about two inches long, is vertical on the inner side of the tibia. Subperiosteal denudation as before. The tibia is sawn with keyhole or chain-saw, the remainder of its attachments carefully severed and the fragment removed, the detached piece of astragalus being removed afterward.

The great objection to the lateral incisions has been the imperfect exposure of the interior of the joint gained when they are used, which leads to the overlooking of points of disease and consequent relapses. Many operators, therefore, prefer the semi-lunar incision in some form, either anterior or lateral. Hancock[59] made an incision which beginning behind and about two inches above the external malleolus passed forward beneath that process across the front of the joint and terminated about two inches above and behind the inner malleolus. The cut divided skin only and the flap was dissected up, the peronei tendons detached from their grooves and drawn aside and the external lateral ligament cut. The fibula was cut off with bone nippers one inch and a half above its lower extremity. The foot was thrown over and the internal lateral ligament cut, the artery being saved and tendons of the tibialis anticus and flexor communis detached from their grooves. The foot was dislocated outward, the lower end of the tibia sawn off about a half-inch above the articulating surface and the astragalus removed.

Ashhurst[60] expresses his preference for "a semi-lunar incision, made to pass around the lower border of the outer malleolus, and then continued longitudinally in the line of the fibula." All tendons are saved except the peroneals, which are divided, the lower end of fibula removed, the astragalus wholly or partly removed. The foot is bent inward, the tibia cleared, its malleolus cut off with bone forceps, a short incision is made on the inner side of the limb, and the tibia sawn with a keyhole saw.

Kocher[61] makes an external semi-lunar incision from outside of the tendo-Achillis below the malleolus nearly to the extensors. The peroneal tendons being exposed, each is tied with a double ligature and cut between the ligature. The joint is freely opened, the foot bent inward, all disease searched for and removed. The divided tendons are reunited by a suture carrying a needle at both ends. Both needles are thrust into the upper segment a little distance apart, out at its cut end, into the cut end of the other segment and out upon the surface at different points the cut surfaces approximated and the suture tied. Kocher thinks that this gives a firmer suture than ordinary stitches.

Hueter[62] favored an anterior transverse cut with subsequent suture of tendons.

Vogt[63] has devised a somewhat novel method. He makes an incision just outside of the extensor tendons, beginning between the tibia or fibula above and running down to the junction of the calcaneum and cuboid. The fascia is divided, the tendons with their sheaths carefully detached from the parts beneath and drawn strongly inward. The extensor brevis is then cut and the outer lip of the wound drawn outward, and the capsule of the joint split open from top to bottom and with knife and elevator detached on both sides from the bone. The head and neck of the astragalus are then cleared and astragalo-scaphoid ligament cut through. Then a second incision is made from the first, beginning rather below the middle of the latter and running backward under the external malleolus. While the peroneal tendons are avoided the cut is carried down to the astragalus. The foot is separated, the ligament is cut away from the front of the malleolus and the interosseous ligament divided by a strong knife thrust into the aperture between the astragalus and os calcis. The foot being still supine the head of the astragalus is drawn outward with a strong hook, the fasciculus of the internal lateral ligament between the malleolus and the astragalus is cut; the latter bone is then drawn forward and its posterior connections cut and the bone removed. Through the cavity thus made all the adjoining bones can be readily examined and the extent of the subsequent resection,

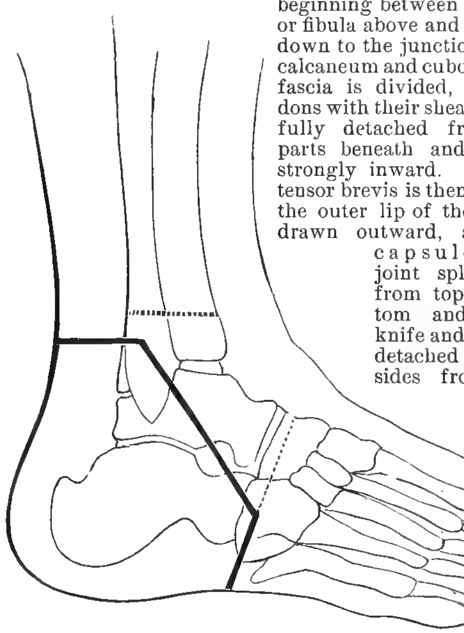


FIG. 3308.

whether with saw, gouge, or spoon depends upon the necessities of the case.

Mikulicz,[64] in 1880, performed what he styles an osteoplastic resection of the foot, which is intended for the relief of extensive disease of, or injury to, the posterior bones of the tarsus or of their covering tissues, and as a substitute for amputation at the ankle or in the leg. It seems[65] that the operation had been done in 1871 by Wladmiroff, but, the published account being in Russian, was overlooked until after Mikulicz had reinvented it. The operation is performed thus: The patient lies upon his stomach. An incision is carried from the tubercle of the scaphoid bone on the inside right across the sole to a finger's breadth behind the base of the fifth metatarsal bone. From each end of this incision others are carried upward and backward to the base of the malleolus of the same side. These again are joined by a cut across the back of the ankle dividing the tendo Achillis (Fig. 3308). All these cuts are carried to the bone. The flap is dissected from above, the joint opened from behind, the lateral ligaments cut, the astragalus and calcaneum are carefully dissected out and detached at the medio-tarsal joint. The malleoli and articular surface of the tibia and the posterior part of the cuboid and scaphoid bones are then sawn off, as shown by the dotted lines. The foot is brought back, the sawn surfaces adjusted, and the wound closed. Fig. 3309 shows the foot resulting in Mikulicz' case. Hopkins modified the operation by using bone pins to secure the parts together, by suturing the divided tendons, and attaching the tendo Achillis to the plantar fascia. The ends of the resected posterior tibial nerve were also sutured. This author has collected twenty-two cases of this operation; two died some months later of pulmonary tuberculosis, one having had a useful foot in the meantime; in one a subsequent resection of the rest of the tarsus was necessary, and in three subsequent amputation was performed. The remaining sixteen have useful extremities.

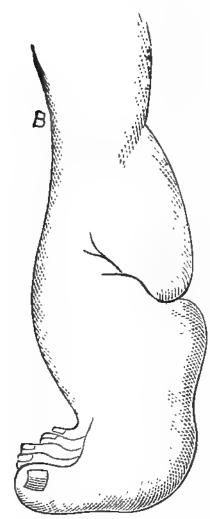


FIG. 3309.

The after-treatment of ankle-resection should be fixation in a good position with as few changes of dressing as practicable. The gypsum bandage or gypsum anterior splints with suspension-rod will suit as many cases as any one form of support. The suspension of the limb is a security against faulty position of the foot.

THE SMALL JOINTS of both the hand and the foot occasionally require excision for the same causes as the larger joints. The indications are those of resections in general under corresponding circumstances, due importance being given to the value of function saved in a finger-joint. For injury informal procedures are generally preferable.

The *phalangeal joints of the fingers* are generally removed through slightly curved lateral incisions, single or double, as necessary.

The *metacarpo-phalangeal joints* are best removed by dorsal straight incisions beside the extensor tendons, the latter being avoided by manipulation. The bone forceps is ordinarily used for section of the bones.

The corresponding *joints of the toes* are removed by the same method as those of the fingers. As the thumb is pre-eminently valuable to the hand, so the great toe is to the foot. In removing the metatarso-phalangeal joint of the great toe, the incision may be on the inside and semilunar in form. The operation has been recommended for hallux valgus, especially if complicated with painful bunion.

In both upper and lower extremity the resected parts should be kept separated by traction until the state of repair permits passive motion. The latter should be begun early, to preserve the function of the joints.

Leroy Milton Yale.

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RESORCIN: RESORCINOL. Resorcin, chemically *Metadioxybenzene*, $C_6H_4(OH)_2$, is one of a trio of isomeric diatomic phenols, of which pyrocatechin and hydroquinone are the other two members.

Resorcin occurs in colorless crystals, having a peculiar smell, resembling that of carbolic acid, and a bitter-sweetish taste. Resorcin dissolves readily in water, and still more readily in alcohol and in ether. In its effects resorcin resembles its congener, carbolic acid, but is, in general, less active than that substance, and, in particular, very much indeed less poisonous, constitutionally. Resorcin inhibits bacterial growth, but probably less potently than carbolic acid. Locally the drug is without effect upon the sound skin, but applied, undiluted, to a moist mucous

membrane, it is mildly caustic, while at the same time anæsthetic and healing. By reason of the anæsthesia it produces, resorcin may be applied even to such sensitive parts as the mucous membrane of the larynx (Andeer). Internally, resorcin may be given in very considerable doses, as compared with carbolic acid, and such doses, administered to a fevered subject, will show to a marked degree the peculiar antipyretic effect so characteristic of the phenols. After a dosage of from 2.00 to 3.00 Gm. (from thirty to forty five grains) there set in, in a few minutes, quickening of heart-action and of breathing, reddening of the face, and buzzing in the ears, with giddiness. Within fifteen minutes sweating begins, speedily becoming active, whereupon the antecedent derangements abate, and at the same time the pyrexial temperature rapidly falls—so rapidly as perhaps to reach the normal point within an hour. The sweating does not last long, so that after the lapse of an hour from the time of dosing, the fever-patient may have a naturally moist skin only, with temperature and pulse-rate reduced to the normal. But while defervescence by resorcin is quick to occur, it is also quick to give way to the natural tendency of the fever to regain its former height. Within from two to four hours, therefore, the temperature often begins its succeeding rise, and within a single additional hour may have attained its original height. Such rapid after-risings of temperature may be attended by a chill. Resorcin is variable in its action; sometimes the fall of temperature is slight, and sometimes the by-effects are excessive and even alarming. Thus, after medicinal doses, there have been observed delirium and illusions, with muttering speech and convulsive trembling of the hands, and, in one case at least, a deep comatose sleep. In overdosage resorcin is competent to induce constitutional poisoning after the general type of poisoning by the phenols—giddiness, insensibility, profuse sweating, great reduction of temperature and general collapse, with olive-green coloration of the urine, being the prominent symptoms. Such alarming condition has followed a succession of doses increased from half a drachm to two drachms. Therapeutically, resorcin is used for both local and constitutional medication. Locally, resorcin is possible for a simple "antiseptic" effect, but is surpassed in this therapeusis by so many other agents as to be little used for the purpose. But for a combined antizymotic and *healing* effect the local application of resorcin may be quite serviceable. Thus injections of a five per cent. aqueous solution have been made into the bladder, in cystitis, and into suppurating cavities, with good effect, and salves of resorcin have abated malignant and syphilitic ulcerations. Internally resorcin has been used for its antipyretic action, in which application the medicine presents the feature of a fair degree of safety and efficiency combined; but the action is evanescent and attended by disagreeable excitement and sweating. The dose of resorcin for an antipyretic effect ranges from 2.00 to 4.00 Gm. (from thirty to forty-five grains), best given in divided doses and administered, dry, in a wafer or capsule, or in solution in water, sweetened and aromatized. Constitutional effects are also asserted (Andeer) to be procurable, in diseases attended by an affection of the skin, by inunction of resorcin in admixture with vaseline, in proportion of from five to eighty per cent., such effects being the abatement of symptoms in so-called zymotic diseases. Andeer claims to have thus produced striking amelioration in such diseases as small-pox, scarlet fever, measles, and leprosy, by inunctions, over the whole body, of resorcin-vaseline. *Edward Curtis.*

RESPIRATION, PHYSIOLOGY OF (Gr., ἀναπνοή, ἀνάπνευσις; Lat., respiratio; Fr., respiration; It., respirazione; Ger., Athmung). There are three distinct conceptions of respiration in medical and popular literature, representing three stages in the progress of knowledge concerning this subject: (1) That it consists of the mechanical process of supplying the lungs with air, gills with water, etc. (see below, under Mechanics of Respiration); (2) that it is the change taking place in the blood during its passage through a respiratory organ (lung or gill) (see below, under External Respiration); (3) the conception held at the present day, that it is the taking up of oxygen and the giving off of carbon dioxide by living matter; or, in other words, it is that part of the nutrient process which has to do with nutriment and waste in the gaseous form, and that the mechanical movements for supplying air or water, and the changes occurring in a respiratory blood, are only accessories of the essential process, and are sometimes absent.

Respiratory Media.—These are the sources from which oxygen is obtained for respiration, and into which carbon dioxide is excreted. They are air, and water containing oxygen in solution. If an animal breathes in the air, its respiration is said to be *aërial*; if in water, *aquatic*. In some cases—in tadpoles, for example—both media are used at the same time.*†

Direct and Indirect Respiration.—In organisms of minute size, like the *amœba*, the living substance is all so near the oxygen in the surrounding medium (water) that oxygen is taken directly from the water, and carbon dioxide is given off directly to it (Fig. 3310). In animals of larger size, especially those of complex organization, if the respiratory medium simply bathed the surface of the body, most of the living matter would be too far from the oxygen supply to enable the organism to carry on its functions with the highest efficiency; hence there are present special respiratory organs to facilitate the furnishing of oxygen to the tissues, and the removal of carbon dioxide from them.

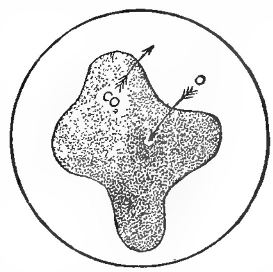

FIG. 3310.—Diagram of an Amœba, Illustrating the Direct Respiration of Minute Aquatic Animals, in which the living substance takes oxygen directly from the surrounding medium, and returns carbon dioxide directly to it, no respiratory organs being present. O, oxygen; CO_2, carbon dioxide.

In the larger *protozoa*, as the *infusoria*, cilia are present on the surface, which, by their motion, produce currents in the water, or change the position of the animal, in either case insuring fresh supplies of the respiratory medium. Water is also taken into the body, thus bringing the oxygen into intimate contact with the living substance farthest from the surface.

In the *metazoa* the size of the body is often considerable, and more elaborate means are employed to bring

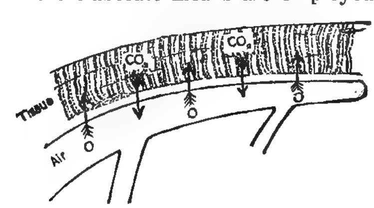

FIG. 3311.—Diagram Illustrating the Direct Respiration of Insects, in which Air is conveyed to the Tissues through Tubes (tracheæ). The tissues take oxygen directly from the air, and return carbon dioxide directly to it, no respiratory blood being present. O, oxygen; CO_2, carbon dioxide. As indicated by the arrows pointing in the two directions, the tissues take more oxygen from the air than they give off carbon dioxide to it. Air, the air in the trachea. Tissue, all the tissues of the insect's body are here represented by a piece of striated muscular fibre.

the respiratory medium in proximity to the living substance. In some of them—the *sponges*, for example—there are water canals in all parts of the body, through which streams of water constantly flow, thus bringing

* In the forms of bacteria known as *anærobic*, *i.e.*, living in situations devoid of free oxygen, the oxygen needed for respiration is, according to Bernard,[1], [2], obtained by breaking up some of the compounds in the surrounding medium.

† When an animal, like a tadpole, employs both air and water as respiratory media at the same time, the carbon dioxide seems to be principally excreted into the water, and the oxygen mainly derived from the air (Science, vol. vii., p. 394, 1886).

the oxygen in contact with the tissues, and removing carbon dioxide from them. In still higher forms—*insects*, etc.—there is a complex system of tubes, called *tracheæ*, extending from the exterior to every organ and tissue, and serving to conduct air to and from every part. The living substance can thus take oxygen directly from the air in the tubes, and return carbon dioxide directly to it, [4,9] (Fig. 3311). It will be seen from the above that what may be properly designated *direct respiration*—that is, taking oxygen directly from the respiratory medium by the tissues, and returning carbon dioxide directly to it by them—is found in both aërial and aquatic animals.

In man and the other vertebrates, also in many invertebrates, this direct respiration is not found, but there is a circulating liquid—*respiratory blood*—containing hæmoglobin or its equivalent, which serves as a carrier of oxygen from the respiratory medium to the tissues, and of carbon dioxide from them back to the respiratory medium in return. There are also present special respiratory organs (*gills* for aquatic and *lungs* for aërial respiration). To make the respiratory organs efficient, there is a complex nervous, muscular, and bony or cartilaginous mechanism for constantly supplying the respiratory organs with fresh air or water, and constantly removing that which has become vitiated. Finally, there is present a complex vascular mechanism for the circulation of the blood.

The form of respiration just described is called *indirect respiration*, for the reason that the tissues do not get the

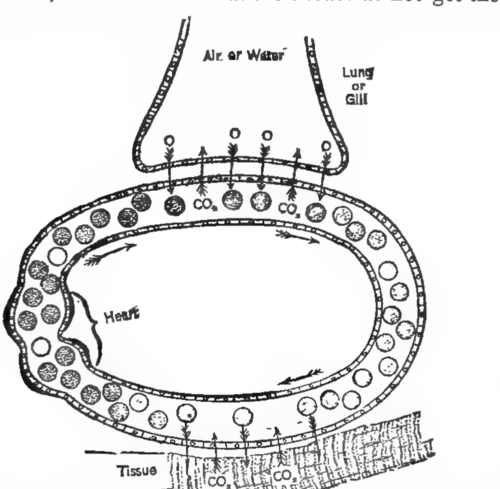

FIG. 3312.—Diagram Illustrating Indirect Respiration by Means of Respiratory Organs and a Respiratory Blood. Air or Water, the respiratory medium bathing the respiratory membrane and supplying the blood with oxygen and removing carbon dioxide from it. Lung or Gill, the respiratory membrane. Heart, the central and motor part of the circulatory system. This system, except at the heart, is represented only by the endothelial lining common to the entire system. The arrows extending along the vessels indicate the direction of the blood-current. O, oxygen; CO_2, carbon dioxide. As indicated by the arrows pointing in the two directions, more oxygen is taken up by the blood and the tissues than there is carbon dioxide given off in return. The diagram also indicates that the carbon dioxide is mainly in the plasma, and the oxygen in the red blood-corpuscles. The presence of the oxygen in the corpuscles gives the blood a lighter color, as indicated by the shading of the corpuscles; as also indicated by the shading of the corpuscles, the arterial blood is not fully saturated with oxygen, nor is the venous blood entirely devoid of it. Tissue, all the tissues of the body are here represented by a piece of striated muscular fibre.

oxygen directly from the air or water, but indirectly through the respiratory blood [1] (Fig. 3312).

RESPIRATORY ORGANS.—In man and the other animals in which a respiratory blood is present, and the respiration is consequently indirect, the respiratory organs consist essentially of a thin expanded membrane, *the respiratory membrane*, [15] bathed on one side by the respiratory medium, and on the other by the respiratory blood, which is spread out in a thin, almost continuous sheet in the capillaries. This respiratory membrane, in man and the mammals generally, is in the form of two great elastic sacs called lungs, in which the surface is repeatedly folded, thus forming an almost infinite number of secondary sacs—the *pulmonary alveoli, vesicles, air-sacs*, or *air cells* (Figs. 3313 and 3317). The lungs are placed in the

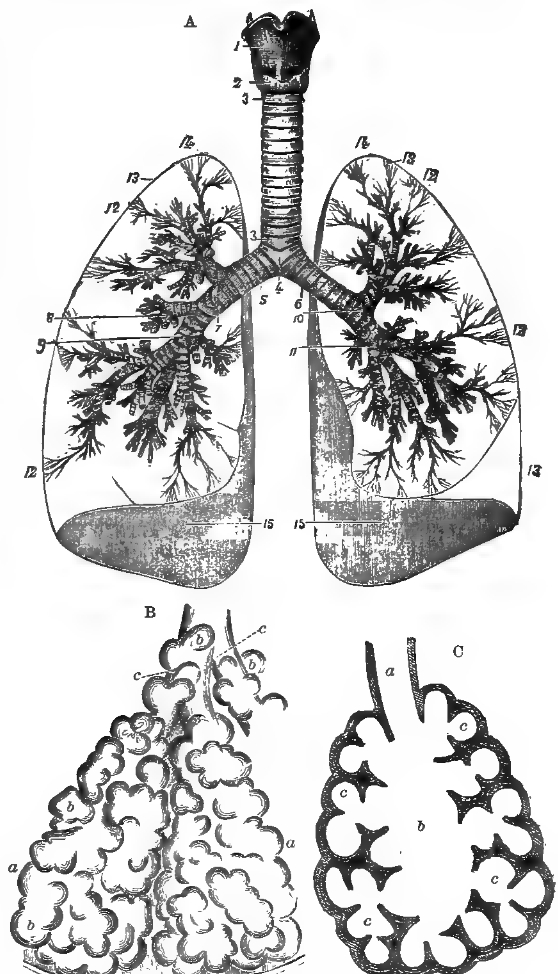

FIG. 3313.—The Trachea, Bronchi, and Ultimate Termination of the Bronchi in the Lungs. (A) Ventral view of the larynx, trachea, and bronchi, and of the lungs in outline and opened so as to show the tree-like branching of the bronchi (Sappey). 1–2, the larynx; 3–3, the trachea; 4, bifurcation of the trachea to form 5 the right, and 6 the left bronchus; 7, division extending to the cephalic or superior, 8 to the middle, and 9 to the caudal or inferior lobe of the right lung; 10, bronchial division to the cephalic or superior lobe, and 11 to the caudal or inferior lobe of the left lung; 12, ultimate ramification of the bronchi; 13, contour of the lungs; 14, summit; and 15, base of the lungs. (B) Two lobules from the lung of a new-born child, half diagrammatic and magnified twenty-five diameters (Kölliker). Three ultimate bronchial tubes or lobular bronchioles are shown, but the terminal lobule is shown on but two of them. *a,a*, Lobules; *b,b*, alveoli or air-vesicles; *c,c*, terminal bronchial tubes or lobular bronchioles. (C) A single lobule in section, magnified (Dalton). *a*, Terminal bronchial tube opening into *b*, the alveolar or lobular passage; *c,c,c,c*, air-vesicles or alveoli. The pulmonary capillaries ramify in the shaded partitions between the alveoli.

air-tight chest or thorax, and communicate with the exterior through the respiratory or air-passages (Fig. 3315). In shape the lungs conform accurately to the cavity left in the thorax by the heart and great vessels; that is, the costal surface of each lung is convex, while the mesal surface is somewhat concave where it is moulded to the surface of the heart. At the base the lungs rest upon the diaphragm, and from their elasticity follow all its varying shapes (Fig. 3319). At the apex the lungs are

bluntly pointed, fitting the corresponding cavity in the cephalic or upper part of the thorax.

In man the right lung is divided into three somewhat unequal lobes by two fissures extending from the costal

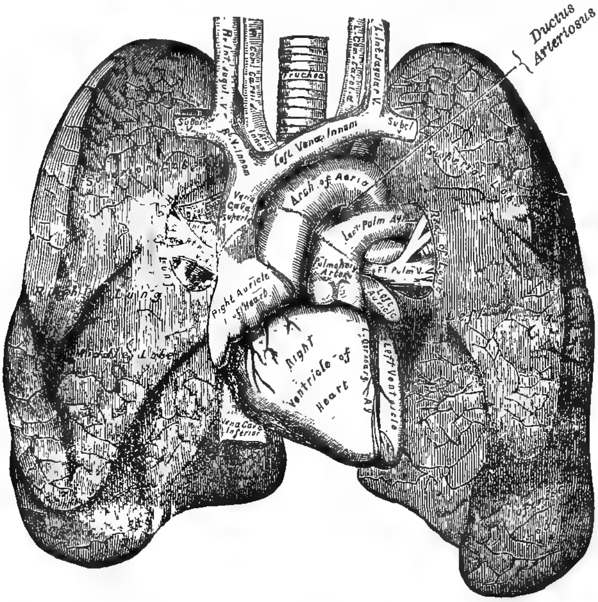

Fig. 3314.—Ventral View of the Lungs, Trachea, Heart, and Great Vessels. (Gray.) The lungs are slightly inflated, and separated so as to bring into better view the heart, etc. The right lung is divided by two fissures into three lobes, and the left one by a single fissure into two lobes.

surface toward the root of the lung. The left lung is divided into two lobes by a single fissure (Fig. 3314). The so-called root of the lung is at the point of suspension of the lung, and each is composed of a bronchus, the pulmonary blood-vessels, lymphatics, and nerves, and the connective tissue binding these structures together (Figs. 3313 and 3314). Each lung is covered by a serous membrane, a reflection of the corresponding pleura, which, commencing at the root, is reflected over the entire surface, entering the fissures and forming a complete envelope for the lung. The connective-tissue layer of the pleura covering the lungs is directly continuous with their connective-tissue framework, so that the pulmonary pleura forms an essential part of the lung-structure.

The *Respiratory* or *Air-passages* are tubes or openings serving to conduct the air to and from the lungs. They are the two nasal passages, sometimes also the mouth, the pharynx, which like the mouth is also common to the alimentary canal, the larynx, trachea, and bronchi (Figs. 3313 and 3314). The bronchi continually divide, like the branches of a tree, without anastomosing, and finally terminate in sac-like enlargements which are the true respiratory parts of the lungs (Figs. 3313 and 3317). From this arrangement of the true respiratory parts of the lung at the ends of the bronchi the lung is sometimes not considered as composed of a great sac, as stated above, with foldings of the surface and a minute bronchial twig connected with each minute fold, but it is supposed to consist of a great number of small, independent sacs closely bound together. On this view, the comparison with a tree, especially one with divided leaves, might be continued, each leaf representing an ultimate lobule of the lung (Figs. 3313 and 3317).

The air-passages of the lungs, and the respiratory passages in the nose, are lined with ciliated epithelium. In each case the motion of the cilia produces a current toward the pharynx. This current carries dust and mucus into the pharynx, from which they are readily expelled. (See also articles on the Bronchi, vol. i., and the Minute Anatomy of the Lung, vol. iv.)

Vascular and Nervous Supply of the Lungs.—The blood going to the lungs is of two kinds and from two sources: (1) The impure or venous blood from the right side of the heart going through the pulmonary artery to the lungs to be purified or arterialized; and (2) pure or arterial blood from the left side of the heart going through the bronchial arteries to the lungs for the nourishment of their substance. The first, after purification, is returned to the left side of the heart by the pulmonary veins. The second, after serving for the nourishment of the lung-tissue, is returned in part through the bronchial veins to the right side of the heart, and in part through the pulmonary veins to the left side of the heart; in other words, part of the arterial blood of the bronchial arteries is returned as arterial blood directly to the left side of the heart from which it was sent, without first passing in the regular way into the systemic veins and the right side of the heart [6, 7]. "In their course together through the lung the artery is usually found above and behind the bronchial tube, and the vein below and in front." [7] The bronchial arteries and their branches ramify in the lung-tissue without such definite relations to the bronchi as with the pulmonary vessels.

The nerves of the lungs are derived from the vagus and the sympathetic, and form a dense plexus on the dorsal and another on the ventral side of the root of each lung (the so-called anterior and posterior pulmonary plexuses). From these plexuses the nerves ramify in the substance of the lung, following the bronchi.

External Respiration.—Under this heading are included the changes which occur in the respiratory blood during its passage through the lungs or gills, and also the changes occurring simultaneously in the respiratory medium.

According to the view of chemists and physicists, the earth's atmosphere, or the air, as it is more commonly called, is a mechanical mixture composed princi-

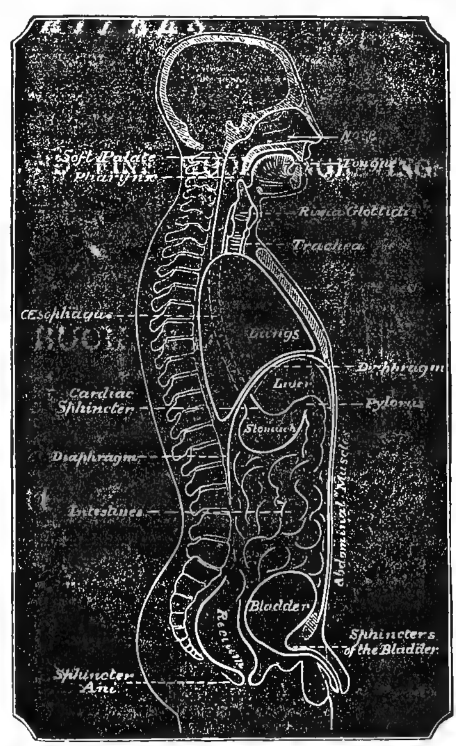

Fig. 3315.—Diagrammatic Section of the Body. (Kirkes.)

pally of oxygen and nitrogen, with a minute quantity of carbon dioxide and a varying amount of watery vapor.

The composition of the air from various parts of the earth's surface has been found nearly uniform. When dried and reduced to the standard temperature and pressure (a temperature of zero centigrade and a pressure of 760 mm. of mercury), the composition is about as follows: *

Oxygen	20.81 per cent.
Nitrogen	79.15 " "
Carbon dioxide	0.04 " "
	100.00 per cent.

Air coming from the lungs (*expired air* or *breath*) of man, or one of the other warm-blooded animals, compared with the inspired or atmospheric air, shows the following changes, due to its sojourn in the lungs: (1) A marked decrease in the amount of oxygen; (2) a great increase in the quantity of carbon dioxide; (3) slight if any change in the amount of nitrogen; (4) usually an increase in the quantity of watery vapor; (5) the temperature is closely approximated to that of the body, being usually warmer than the surrounding air; (6) traces of organic matter have been added; (7) traces of ammonia are often present, and sometimes odors from substances taken into the stomach, as alcohol, garlic, etc.

The surrounding air is usually at a lower temperature than the body, and is therefore heated by the body when taken into the lungs. In this case it increases in volume, following the law for the expansion of gases by heat. If the temperature of the air is higher than the body, it is cooled by being inspired and diminishes in volume, following the same law. But after making allowance for changes in temperature and in the amount of aqueous vapor present, the expired air is usually slightly less in volume than the inspired air, due to the fact that the volume of oxygen absorbed from it is greater than that of the carbon dioxide added to it. This diminution is variously estimated from 1 to 2.5 per cent. of the original volume inspired.

Owing to the change in volume, a comparison of the percentage composition of inspired and expired air does not furnish exact information concerning the quantitative changes which the air undergoes in the lungs. These changes can only be determined accurately by comparing the absolute amount of the various constituents of a known volume of inspired air with the absolute amount of the various constituents of the same air after it is expired.[8] †

Gases of the Blood.—It was thought by Lavoisier,[9] and those who followed his teachings, that carbon dioxide was formed in the lungs by an oxidation of the waste materials brought to the lungs by the blood. This view was found untenable by later investigators, who proved that the arterial blood was cooler than the venous. This could not be the case if oxidation sufficient to produce all the carbon dioxide appearing in the expired air took place in the lungs. It was also shown that, in blood from any part of the body, carbon dioxide and oxygen could be obtained directly without chemical means; and that more carbon dioxide could be obtained from venous than from arterial, and more oxygen from arterial than from venous, blood. At the present day it is known that the respiratory process occurring in the lungs is an absorption of oxygen from the air by the blood, and a return to the air of carbon dioxide already existing in the blood.

The exact office of the blood in respiration could only be determined by discovering the nature and relations of the gases of arterial and venous blood.[20] *

From one hundred volumes of blood about sixty volumes of gas may be extracted. This does not diminish the volume of the blood. The gas is composed of oxygen, nitrogen, and carbon dioxide, the proportions of these gases varying in the different kinds of blood.

In order that the results shall be of the greatest value, the two kinds of blood from which the gases are extracted should be from the same animal, under similar conditions. According to five such double analyses of dog's blood by Schoeffer,[8] the following averages were obtained from 100 c.c. of blood:

Arterial Blood: Oxygen, 19.2 c.c.; nitrogen, 2.7 c.c., carbon dioxide, 39.5 c.c.

Venous Blood: Oxygen, 11.9 c.c.; nitrogen, 1.7 c.c.; carbon dioxide, 45.3 c.c.

This table shows that in 100 c.c. of arterial blood there are 7.3 c.c. more oxygen, and 5.8 c.c. less carbon dioxide than in the same volume of venous blood. From numerous determinations made by other observers, Zuntz gives as an average, an increase of 8.15 per cent. of oxygen and a decrease of 9.2 per cent. of carbon dioxide in 100 c.c. of arterial blood as compared with the same volume of venous blood. According to the very numerous (nearly two hundred) determinations of the gases of arterial blood of the dog by Bert and Pflüger, the gases in 100 c.c. of blood are as follows:[8] Oxygen, 18 to 20 c.c.; nitrogen, 1 to 2 c.c.; carbon dioxide, 38 to 40 c.c. In human arterial blood the gases were found by Setschenow[8] in the following quantities in a single determination: Oxygen, 21.6 c.c.; nitrogen, 1.6 c.c.; carbon dioxide, 40.3. So far as this single determination goes, the gases in human blood agree very closely in quantity with those found in dog's blood, and any conclusions drawn from observations on the gases of dog's blood might probably be legitimately applied to human blood.

Arterial blood is of nearly uniform composition throughout the entire body, containing a slightly less percentage of oxygen in the smaller arteries farthest from the heart, due to the diminished number of blood-corpuscles as shown by the lower specific gravity,[8] and in part, probably, also to the true respiration occurring in the blood itself. The venous blood differs considerably in composition in different parts of the body, hence that for the extraction of the blood-gases should be taken from the right heart or the pulmonary artery, where it is mixed, if a general average is sought. A comparison of the gases of arterial and venous blood from any part of the body shows, however, wherein lies the difference between them so far as respiration is concerned, and it is found to be a difference only in the proportions in which oxygen and carbon dioxide are present in the two kinds of blood. Arterial blood may, therefore, be defined as blood containing a relatively large percentage of oxygen (eighteen to twenty per cent.), and a relatively small percentage of carbon dioxide (thirty-eight to forty per cent.).

Venous blood may be defined as blood containing about eight per cent. less oxygen and six to eight per cent. more carbon dioxide than is present in arterial blood. In ordinary respiration the blood is not saturated with either of the respiratory gases, as is shown by shaking blood

* While it was formerly supposed that the composition of the atmosphere in a given place was constant, later investigations have shown that there is considerable variation; the oxygen has been found to vary from 20.45 to 21.01 per cent., and the carbon dioxide from 0.0206 to 0.0417 per cent.[8]

† It is apparently assumed by many writers on respiration that, if the percentage composition of inspired air and that of expired air are compared, one can determine accurately the changes occurring in the air during its sojourn in the lungs, thus neglecting the diminution in volume. For example, in the excellent works of Wundt (Physiologie des Menschen, 4th ed., p. 388), and Foster (Text-book of Physiology, 3d ed., p. 341), percentage compositions of inspired and expired air are given with the statement that, when dried and compared at the standard temperature and pressure, the expired air is $^1/_{50}$th to $^1/_{40}$th less in volume than the same air when inspired.

Inspired air: Oxygen, 20.81 per cent.; nitrogen, 79.15 per cent.; carbon dioxide, 0.04 per cent.

Expired air: Oxygen, 16.033 per cent.; nitrogen, 79.557 per cent.; carbon dioxide, 4.38 per cent.

The loss in oxygen by the air, and its gain in carbon dioxide, are both determined by comparing the percentage differences, without apparently taking any account of the diminution of volume. It is further stated by Dr. Foster, with reference to the nitrogen: "The quantity of nitrogen in the expired air is sometimes found to be greater, as in the table, but sometimes less, than that of inspired air." While it is true that the *percentage* quantity of nitrogen in the expired air is greater, as shown in the table, the absolute amount is less, provided there is the diminution in volume described. Taking the least diminution mentioned, $^1/_{50}$th or 2 per cent., then 100 c.c. of inspired air would measure but 98 c.c. when expired. If, now, 79.557 per cent. of this is nitrogen, the total nitrogen in the 98 c.c. of expired air would be $(98 \times 79.557) = 77.96586$ c.c.; and as in the 100 c.c. of air originally inspired there were 79.15 c.c. of nitrogen, there has been an actual diminution of $(79.15 - 77.96586) = 1.18414$ c.c. of nitrogen, instead of an increase as stated by Dr. Foster.

* The terms *arterial* and *venous blood* are unfortunately used in two senses, viz., in a morphological sense, relating to the kind of blood-vessel containing the blood without regard to its quality, and in a physiological sense, referring solely to its quality without regard to the vessel containing it. The terms are used only in the latter sense in the present article.

with them. If shaken with pure oxygen or with air, blood will take up about twenty-three per cent. of its volume of oxygen, instead of twenty per cent. as in ordinary respiration, and if it is shaken with pure carbon dioxide the blood will absorb about its own volume of that gas.[10]

Relations of the Gases in the Blood.—It is believed that but a small amount is in simple solution, but that the greater part is in loose chemical combination. This is supported by the fact that when blood is put under the mercurial pump (Fig. 3316), a small amount of gas is gradually given off, following the Henry-Dalton law for the absorption of gases by liquids; but the larger part of the gas comes off only when the pressure falls to about twenty millimetres of mercury; then it is suddenly given off.

The oxygen simply dissolved in the blood plasma has been found to exceed but little the amount that water dissolves at the same temperature. It has been proved conclusively that the main part of the oxygen in the blood is combined with the hæmoglobin in the red blood-corpuscles (see also article Blood, vol. i.). The relations of the carbon dioxide are not quite so simple, for although the blood contains less carbon dioxide than would be absorbed by water at the same temperature, it does not follow the law for the absorption of gases by liquids; and it is the prevailing belief among physiologists that it is all chemically combined in the plasma of the blood, very little being in the corpuscles.[6] As part of the carbon dioxide is readily removed from the blood by the mercurial pump, it is called the "loose" carbon dioxide, and is supposed to be united with the soda of the blood in the form of a bicarbonate; while the part ("fixed" carbon dioxide) which cannot be pumped from the blood serum without first adding an acid, is supposed to be united to the soda in the form of a carbonate. It has been found by experiment that in removing the blood-gases the hæmoglobin acts like an acid, enabling all the carbon dioxide to be pumped out without adding an acid. If the red corpuscles containing the hæmoglobin are first removed, only the "loose" carbon dioxide can be obtained, as stated above, unless an acid is first added.[8] The nitrogen in the blood seems to be in simple solution.

Color of the Blood.—It has been found that hæmoglobin containing oxygen (*oxyhæmoglobin*) is of a bright scarlet color, *i.e.*, the color of arterial blood, while hæmoglobin not containing oxygen (*reduced hæmoglobin*) is of a darker color, that is, the color of venous blood (Fig. 3312). This is true of the hæmoglobin in the blood, whether it is in the blood-corpuscles or dissolved in the plasma, and it is entirely independent of the carbon dioxide that may be present. This is shown by the blood of animals dying of carbon dioxide poisoning in a confined atmosphere of pure oxygen, [9,11]. Under ordinary circumstances, however, the color of the blood is a good test for determining its respiratory quality, as carbon dioxide escapes at the same time that oxygen is absorbed. But it is truly arterial only when its hæmoglobin is nearly saturated with oxygen and the plasma contains a moderate amount of carbon dioxide (see above).

Gas-interchange in the Lungs.—When the venous blood reaches the lungs it is spread out in a thin sheet in the pulmonary capillaries and separated from the air on two sides, in many places only by the epithelium of the capillaries and that lining the alveoli of the lungs (Fig. 3317). The blood being thus practically in contact with the air, oxygen passes through the membrane separating the air from the blood into the blood, in accordance with the law for the absorption of gases by liquids; but as soon as it reaches the blood-plasma, the reduced hæmoglobin combines chemically with it to produce oxy-

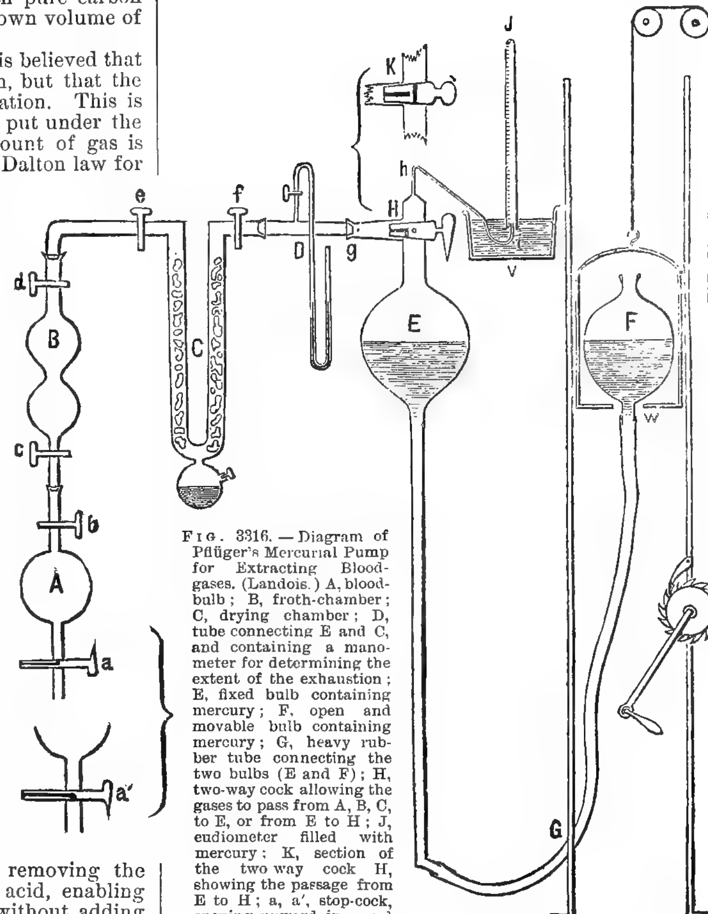

FIG. 3316.—Diagram of Pflüger's Mercurial Pump for Extracting Blood-gases. (Landois.) A, blood-bulb; B, froth-chamber; C, drying chamber; D, tube connecting E and C, and containing a manometer for determining the extent of the exhaustion; E, fixed bulb containing mercury; F, open and movable bulb containing mercury; G, heavy rubber tube connecting the two bulbs (E and F); H, two-way cock allowing the gases to pass from A, B, C, to E, or from E to H; J, eudiometer filled with mercury; K, section of the two way cock H, showing the passage from E to H; a, a′, stop-cock, opening upward in a, and downward in a′; b, c, d, e, f, stop-cocks; g, connection between the collecting and drying part of the apparatus and the pump; h, glass tube connecting the bulb E with the eudiometer J: i, mercury into which the eudiometer and the tube h dip; v, dish of mercury (pneumatic trough); w, support in which the bulb F is raised and lowered by the ratchet-wheel shown at the right. The following directions for the use of this pump are taken from Landois: The blood-bulb A is first exhausted by means of a mercurial pump, and then carefully weighed. The end of the stop-cock a is tied into a blood-vessel and the cock turned so that the blood flows into the blood-bulb. When a sufficient amount of blood is collected the cock is turned in the position (a′), and after cleaning the outside of the blood-bulb it is again carefully weighed to ascertain the amount of blood that has been collected. The froth-chamber (B), as its name implies, is to catch the froth formed during the energetic evolution of the blood-gases. It is connected with the other parts of the apparatus, on both sides, by means of stop-cocks. The drying chamber C is composed of a U-tube filled with pumice stone saturated with sulphuric acid, and at the base of the U-tube is a bulb partly filled with sulphuric acid. The blood-gases in traversing this chamber are completely dried. In working the pump, the whole apparatus is emptied of air by filling the bulb E with mercury, by raising the bulb F, after turning the cock H in the position K, so that the air in E can pass out through the tube h, which is not yet dipped into the mercury, and then turning the cock H so that it will connect with the rest of the apparatus. All the other cocks except a and b are opened, and the bulb F is lowered until part of the air is exhausted, then the cock H is turned to the position of K and the air is got rid of by raising F. This process is repeated until the manometer in D shows a complete vacuum. Then the cock H is turned to the position K, and the bulb F raised until mercury runs out of the tube h, when the cock is turned to the position H, and the tube h is placed in the pneumatic trough v, under the eudiometer J. A vessel of water at about 60° C. is now raised so as to immerse the blood-bulb, and the cocks, except a, are opened and the bulb F lowered. After part of the gas has passed over to E, the cock H is turned to the position K, and the gas is forced over through the tube h into the eudiometer J. This process is repeated until, as shown by the manometer in D, the gases are all extracted.

hæmoglobin, leaving the plasma as poor in oxygen as before. The absorption of oxygen by the plasma there-

fore continues until all the reduced hæmoglobin is oxidized and changed to oxyhæmoglobin, and the plasma is saturated with oxygen at the temperature of the blood and the partial pressure or tension of the oxygen in the alveolar air.*

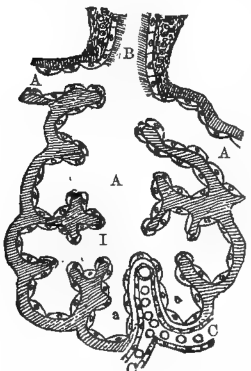

FIG. 3317.—Diagram of Part of a Pulmonary Lobule, to Show the Relations of the Various Parts, especially the Blood Capillaries and the Alveoli. A, A, A, Alveolar or lobular passages; a. a, pulmonary alveoli, air-vesicles, or air-cells. These open either into the alveolar passages singly or in groups; B, ultimate bronchial tube or lobular bronchiole. It is lined with ciliated epithelium and opens into the alveolar passages on one side and joins other bronchioles on the other; C, C, capillary containing blood-corpuscles. The capillary is exposed to the air on two sides, being separated from the air only by the epithelium lining the alveoli. In the actual specimen all the partitions are filled with capillaries; I, opening into the alveolar passage of an infundibulum or group of alveoli.

This explains why the oxygen needed for respiration is obtained by the blood independently of the partial pressure or tension of the oxygen in the air, provided the tension does not fall too near the point of dissociation of oxyhæmoglobin; for, according to the law of absorption of gases by liquids, a certain amount of oxygen enters the plasma of the blood whether there is a greater or less amount of oxygen in the air than normal. The reduced hæmoglobin combines with the oxygen to produce oxyhæmoglobin independently of the tension of the oxygen. If the air is very rich in oxygen, the hæmoglobin of the blood is quickly changed to oxyhæmoglobin, for a sufficient amount is rapidly absorbed by the plasma and thus brought into combining distance of the hæmoglobin. If, on the other hand, the tension or partial pressure of the oxygen in the alveolar air is small, the hæmoglobin will still combine with the same amount, but it will take a longer time, from the slowness with which the oxygen is absorbed and brought into combining distance by the plasma.

At the same time that the oxygen is passing from the alveolar air into the blood, carbon dioxide is passing from the blood to the air; hence the designation of the process as an *exchange of gases.* The same principles are supposed to govern the exit of carbon dioxide as for the absorption of oxygen—the air in the alveoli of the lungs contains carbon dioxide at a less tension than it possesses in the blood, so that the excess of carbon dioxide tends to pass from the blood to the air to establish equilibrium. The case is not so simple as this, however, for, as the entire amount of carbon dioxide in the blood is in combination, it could not be expected to follow the laws of diffusion determined by difference of tension. If it is in true chemical combination it has no tension in the blood. The explanation has been sought in the fact that oxyhæmoglobin acts as an acid in setting free the carbon dioxide, and this action seems to be all the more energetic at the moment when the oxygen is taken up to form the oxyhæmoglobin. The pulmonary epithelium covering the alveoli (Fig. 3317) is also supposed to assist by actively excreting carbon dioxide. Finally, as the amount of carbon dioxide in venous blood may be represented by a tension of 41 mm. hg., and the partial pressure or tension of the air in the pulmonary alveoli is only 27 mm. hg.,[6] it is supposed that this difference in tension is sufficient, with the assistance of the acid-like action of the oxyhæmoglobin, to dissociate the combined carbon dioxide, when it would be subjected to the laws of absorption of gases, and would escape to the air of the alveoli, where the carbon dioxide tension is lower. Certain it is that this transfer is constantly taking place. Equilibrium would, however, soon be established between the gases of the blood and the alveolar air if either or both were stationary; but both are constantly changing, the one by diffusion and currents, the other by circulation; hence equilibrium is never established, and the respiratory gas-interchange between the blood and the air in the lungs is continuous throughout the whole of life.

INTERNAL OR TISSUE RESPIRATION.—The question still remains to be answered: "What is the ultimate destiny of the oxygen removed from the air, and what is the source of the carbon dioxide added to it?" After it was conclusively shown that the formation of carbon dioxide did not take place in the lungs, it was supposed that its formation took place in the blood in all parts of the body, the oxygen taken up in the lungs serving to oxidize the waste matter poured into the blood. This view was found to be untenable, for very easily oxidizable substances, like pyrogallic acid, do not become oxidized when placed in the blood of a living animal;[12] and if the arterial blood is followed in its course throughout the body, it is found that while the blood in the arteries is of nearly uniform character, as soon as it comes into intimate contact with the tissues in the capillaries the oxygen markedly diminishes, and the carbon dioxide greatly increases, in amount. That the oxygen diminishes in amount during its passage through the tissues may be demonstrated on a living animal by examining the light which traverses some thin membrane like a frog's web, or the wing of a bat, through a spectroscope. The light will show the two bands characteristic of oxyhæmoglobin (see articles Blood and Blood-Stains, vol. i.). If the leg of the frog, or the wing of the bat, is compressed sufficiently to stop the circulation, the single band characteristic of reduced hæmoglobin will soon appear, showing that the oxygen has been given up by the oxyhæmoglobin. According to Vierordt[10] the same may be observed in man by examining through a spectroscope the light which traverses the crack between two fingers. The two bands of oxyhæmoglobin will appear as long as the blood circulates freely; but if a string be wound tightly around the fingers, thus stopping the circulation, the single band of reduced hæmoglobin will soon appear. These demonstrations do not show, however, that the waste material was not first poured into the blood of the capillaries and oxidized there. That it is the tissues that take up the oxygen and give out the carbon dioxide, and that the carbon dioxide is not produced in the blood, is definitely proven by the following: If a living tissue, muscle for example, is removed from an animal and deprived of blood, and placed in a vacuum, or an atmosphere of pure nitrogen or hydrogen, the muscle will continue to produce carbon dioxide, and if irritated will contract, showing that it is alive. If it

* *Partial Pressure, Tension.*—Although these subjects belong to physics, a brief consideration of them may not be out of place, since the terms are so often used in discussing the interchange of gases in respiration. So far as a mixture of gases, unconnected with liquids, is concerned, these two expressions are used interchangeably. The meaning is, that as gases in a mixture exert no pressure upon each other, each exerts such a pressure or has such an expansive force as though it existed alone. This expansive force or pressure is expressed in millimetres of mercury, measured at the standard temperature and pressure (temp., 0° C.; bar., 760 mm. hg.); hence, the partial pressure or tension of a gas in a mixture is obtained by multiplying the atmospheric pressure by the percentage volume of the given gas. Thus, the oxygen of the air forms 20.81 per cent. by volume of the atmosphere; hence its partial pressure or tension is 760 × 20.81 per cent. = 158.156 mm. hg. Knowing the partial pressure in millimetres of mercury, the corresponding percentage by volume is readily obtained by reversing the above process; thus, 158.156 ÷ 760 = 20.81, the per cent. by volume desired.

When a gas is dissolved in a liquid, the term tension alone is applied to it. This means the force by which the gas tends to escape from the liquid. The tension in this case is also expressed in millimetres of mercury or in percentages by volume of the gas. When either of these is known, the other is obtained, as described above for the partial pressure of a gas in a mixture. The tension in millimetres of mercury and the corresponding percentage by volume indicate the amount of the given gas which should be present in an atmosphere overlying the liquid, in order that none of the gas shall escape from the liquid and that no more shall be absorbed. It has no reference to the absolute amount of gas absorbed by a liquid. That varies with each liquid and each gas.

In general, in two gases, a gas and a liquid separated or not by a membrane, or in two liquids separated by a membrane, if there is a difference in the tension or partial pressure of the same gas in the two situations, or a difference in the tension of the given gas in the liquids, or in the liquid and the overlying air, there will be a diffusion of gas from the situation in which the given gas is at the higher, to that in which it is at the lower, tension, and this will continue until equilibrium is established. On the other hand, if the tension is already the same in the two situations, no diffusion of the gas will occur.

is placed in an atmosphere of oxygen or in the air, oxygen will be taken up directly, and carbon dioxide be given off directly, as described in the direct respiration of the amœba, etc. If muscle or other living tissue is placed in arterial blood, some of the oxygen will disappear, and carbon dioxide will appear in its place. Finally, Oertmann and Pflüger have shown that in frogs in which the blood had been entirely replaced by normal salt solution, the respiratory changes take place in a normal manner for a considerable time, and are nearly as great as when the blood was present.

From the facts just stated, and many others, physiologists feel warranted in asserting that the tissues take up the oxygen and give off the carbon dioxide—that is, the true respiratory process occurs in them, and not in the lungs or in the blood. If the first knowledge concerning respiration had been obtained from animals in which

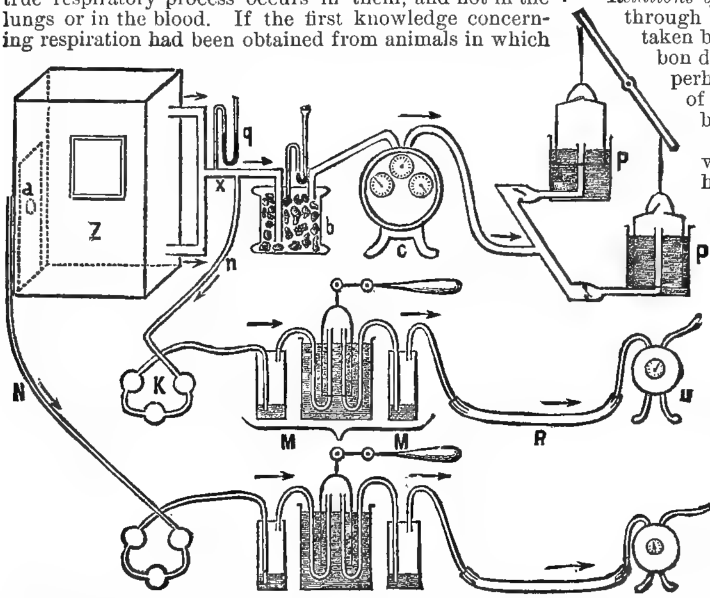

FIG. 3318.—Pettenkofer's Respiration Apparatus. (Landois.) a, opening in the respiration chamber for the entrance of air; b, vessel containing pumice-stone saturated with sulphuric acid, for drying the expired air; C, gas-meter for measuring the air from the respiratory chamber after it is dried; K, bulb containing sulphuric acid to dry the expired air that is to be analyzed; M, M, suction apparatus constructed on the principle of Müller's mercurial valve, and driven by a steam-engine; n, small tube conducting part of the air from the respiratory chamber to the analyzing apparatus, where its composition is determined; N, apparatus for analyzing the air before it enters the respiratory chamber; P, P, double suction-pump, driven by a steam-engine, for drawing the air through the respiratory chamber; q, manometer; R, tube filled with a standard baryta solution, for determining the carbon dioxide; u, small gas-meter to measure the analyzed air, less the carbon dioxide and the watery vapor; x, exit-tube from the respiratory chamber. The air from both the top and the bottom of the respiratory chamber is drawn into this tube, so that it shall be of an average quality; Z, respiratory chamber in which the person or animal remains during the experiment.

the respiration is direct (see above), no respiratory blood or elaborate apparatus being present, it would have been seen from the beginning that respiration is solely for the tissues, no matter how elaborate the appliances for supplying the oxygen and removing the carbon dioxide.[1,6,8,9,12]

The laws governing the gas interchange between the blood in the capillaries and the tissues are supposed to be the same as those obtaining in the lungs, viz., the oxygen-tension in the tissues and the lymph bathing them is far lower than in the blood-plasma, hence diffusion toward the tissues occurs. This goes on until the oxygen-tension in the plasma is so low that the dissociation of some of the oxyhæmoglobin follows, raising once more the tension in the plasma above the dissociating point; but as the tissues are continually taking the oxygen and combining it, the oxygen-tension of the plasma soon falls again below the dissociating point, and more oxygen is given off to it by the oxyhæmoglobin. This process is continuous, for as fast as the oxygen comes into combining distance in the tissues, it is united in a compound more stable than oxyhæmoglobin; consequently, no matter how low the oxygen-tension may fall in the lymph surrounding the tissues, the oxygen compounds formed by them are not dissociated, and the oxygen-tension in the tissues outside the blood-vessels is always lower than in the blood; consequently the diffusion of the oxygen is always away from the blood toward the tissues.

The carbon dioxide in the tissues and lymph surrounding them is at a considerable, and always increasing, tension, while in the blood it has practically no tension, as it is all in combination, and there is a continuous diffusion of the carbon dioxide from the position of higher tension in the tissues to that of a lower tension in the blood.

The blood itself is a tissue, and all the respiratory processes go on in it as in any other tissue.

Relations of the Oxygen in the Tissues.—The changes through which the free oxygen passes after it is taken by the tissues, before reappearing in the carbon dioxide or other excretory product, belongs, perhaps, more properly to the general subject of nutrition, yet a brief discussion may not be out of place here.

The oxygen is probably combined, in some way, with other chemical substances into the highly potential or explosive forms of matter which, in breaking up, give rise to the special form of activity characteristic of the special tissue, and leave less potential compounds, one of which is invariably carbon dioxide. This is shown from the fact that if a muscle, for example, is removed from the body, and freed from blood, it yields no oxygen to the mercurial pump, showing that neither free oxygen nor that loosely combined is present; yet the muscle will contract vigorously when stimulated, and it gives off carbon dioxide continuously—more during the contraction than at rest. As there was no free oxygen present, the carbon dioxide must have been formed by the breaking up of some compound containing oxygen previously stored in the tissue. That this is also true of an entire animal, as well as for the individual tissues, was proved by Spallanzani, Edwards, and Pflüger, who kept frogs, at a low temperature, in an atmosphere of pure nitrogen or hydrogen, for several hours—that is, much longer than the slight amount of oxygen remaining in the air of the lungs or in the blood could have lasted—yet the animals continued to live and produce carbon dioxide. This could not have been the case if oxygen had not been stored in the tissues previous to the experiment.

From what was said under the head of *External Respiration* it is evident that the free oxygen disappearing from the air in the lungs is not immediately returned to the same air, combined with carbon, in the form of carbon dioxide, for it has been shown that this combination does not take place in the lungs; so, likewise, the carbon dioxide returned to the blood of the capillaries does not contain the same oxygen that had been just taken up from the blood by the tissues; but it may have been stored in them, forming part of their living substance for a considerable time. The time intervening between the absorption of the oxygen and its reappearance in the carbon dioxide depends, no doubt, somewhat on the bodily activity of the animal. It is certain that man and the other warm-blooded animals, in which the processes of life are carried on with great vigor, can endure the deprivation of oxygen as well as of other food for a shorter time than the cold-blooded animals.

The Respiratory Income and Outgo, and the Circumstances Affecting Them.—As the oxygen disappearing and the carbon dioxide appearing in respiration have been traced to the tissues, the respiratory activity of

the tissues can be ascertained by determining the amount of oxygen supplied to them and the carbon dioxide excreted. A determination of the total gas-interchange in the lungs will not, however, give the total amount of oxygen absorbed, and of carbon dioxide excreted, as there is a considerable gas-interchange taking place through the skin and through mucous surfaces other than the lungs. The respiratory interchange through the skin, in man and the other animals with a thick and comparatively dry epidermis, is a very small fraction (about $\frac{1}{200}$) of that taking place in the lungs. According to the determinations of Aubert and Lange, the average amount of carbon dioxide excreted by the skin in twenty-four hours is about four grams, or 2,000 c.c. This amount is increased by an elevation of temperature in the surrounding air. Part of this carbon dioxide is not due to respiration, but to decomposition going on at the surface of the skin (Hoppe-Seyler [13]). The amount of oxygen absorbed by the skin is less than the carbon dioxide excreted in the proportion of 100 c.c. of oxygen to 128 to 610 c.c. of carbon dioxide.[6,8]

It is comparatively easy to determine the amount of respiratory gas-interchange going on in the lungs and through the skin; but it is difficult or impossible to determine directly the change through the mucosa of the nose and that of the alimentary canal from swallowed air; consequently, in determining the total respiratory changes going on in an animal, such a method as that of Pettenkofer's, in which the entire income and outgo of the animal is ascertained, must be used (Fig. 3318). It is desirable, however, to estimate the part taken in the total gas-exchange by the different organs involved, so that the part played by each may be known.

In the method of Pettenkofer the amount of carbon dioxide excreted is determined directly, but the amount of oxygen absorbed is determined indirectly, as follows: To the weight of the person or animal at the beginning of an experiment is added the weight of solid and liquid nourishment taken during the experiment; this sum is then subtracted from the weight of the body at the end of the experiment, plus the solid, liquid, and gaseous excreta. The difference represents the oxygen used by the animal during the experiment.

From data furnished in the table in the next column, and by other investigators, the total amount of oxygen taken up by an adult man in 24 hours averages about 750 grams (523,088 c.c.), and the carbon dioxide excreted in the same time averages about 900 grams (456,514 c.c.). The oxygen reappearing in the carbon dioxide is considerably less than that absorbed during the same time. This may be readily seen by comparing the volume of the two gases, as one volume of oxygen when united with carbon forms but one volume of carbon dioxide gas. The diminished amount of the oxygen appearing in the carbon dioxide is explained from the fact that part of the absorbed oxygen is used in forming compounds other than carbon dioxide.

TABLE FROM PETTENKOFER AND VOIT, SHOWING THE TOTAL GAS-EXCHANGE, THE RESPIRATORY QUOTIENT, AND THE AMOUNT OF WATER EXCRETED IN TWENTY-FOUR HOURS BY A MAN UNDER VARIOUS CONDITIONS OF FOOD AND ACTIVITY: [13]

Diet, etc.	Carbon dioxide excreted.		Oxygen absorbed.		Respiratory quotient.		Water excreted.	
	Grams.		Grams.				Grams.	
I. Fasting.								
Rest, day	427	738	450	780	0.69	0.69	444	829
Rest, night	312		330		0.69		385	
Rest, day	379	695	420	743	0.66	0.68	463	814
Rest, night	316		323		0.71		351	
Labor, day	930	1,187	922	1,072	0.73	0.81	1,425	1,777
Labor, night	257		150		1.24		352	
II. Mixed diet.								
Rest, day	533	912	235	709	1.75	0.80	344	828
Rest, night	379		474		0.58		484	
Rest, day	539	943	469	919	0.84	0.74	534	1,009
Rest, night	404		450		0.65		475	
Rest, day	527	930	418	867	0.92	0.78	446	957
Rest, night	403		449		0.65		511	
Labor, day	885	1,285	295	955	2.18	0.98	1,095	2,042
Labor, night	400		660		0.44		947	
Labor, day	828	1,134	795	1,006	0.76	0.82	1,035	1,412
Labor, night	306		211		1.06		377	
III. Diet largely nitrogenous.								
Rest, day	580	1,003	632	850	0.67	0.86	696	1,110
Rest, night	423		218		1 41		414	
Rest, day	596	1,038	566	876	0.77	0.86	644	1,207
Rest, night	442		310		1.04		563	
IV. Diet non-nitrogenous.								
Rest, day	508	839	523	808	0.71	0.74	566	925
Rest, night	331		285		0.84		359	
Rest, day	522		551		0.69		681	

Following Pflüger, most physiologists designate the relation or ratio between the volume of carbon dioxide excreted and the volume of oxygen absorbed in a given time as the respiratory quotient $\left(\frac{CO_2}{O}\right)$. This ratio varies considerably with different conditions of the body, as will be seen below and by consulting the table above.

The respiratory activity of man is greater than that of animals larger than himself, but less than that of many at least of the warm-blooded animals smaller than himself, as will be seen from the following table. In this table the amounts given represent what each animal, retaining its normal respiratory activity, would show if it weighed one kilogram and the experiment continued one hour: [8]

Name of animal and total weight in kilograms.	Oxygen absorbed per hour and kilogram.		Carbon dioxide excreted per hour and kilogram.		Respiratory Quotient, $\frac{CO_2}{O}$	Authority.
	Grams.	Cubic centimetres.	Grams.	Cubic centimetres.		
Man, 60	0.518	361	0.619	314	0.869	Speck.
Ox, 650	...	...	0.437	217	...	Pettenkofer and Voit.
Bull-calf, 115	0.481	336	0.571	290	0.862	Reiset.
Sheep, 66	0.490	343	0.671	341	0.994	"
Dog, 6.393	1.164	814	1.188	604	0.742	Regnault and Reiset.
Rabbit, 2.780	0.877	613	1.107	563	0.918	" "
Hen, 1.280	1.058	740	1.327	675	0.913	" "
Sparrow, 0,022	9.595	6,710	10.492	5,334.5	0.795	" "
Frogs	0.083	58.8	0.063	44.23	0.741	" "
Cockchafers	1.076	752	1.1699	594 8	0.791	" "

Conditions Affecting the Respiratory Gas-interchange.—Bodily activity of any form exerts two influences: the absolute amount of oxygen absorbed and of carbon dioxide excreted are both greatly increased. The relative amount of the two gases is more nearly equal during action than at rest. In some cases of activity and apparent rest this quotient may approach or even exceed unity, showing that oxygen stored at some previous time is being drawn upon (see table from Pettenkofer and Voit).

Sleep and *hibernation* being conditions of profound repose, the respiratory activity is greatly lessened. The relative amount of oxygen absorbed increases in most cases, showing that oxygen is being stored for future use. The respiratory quotient consequently falls considerably below unity. In hibernating animals this quotient may fall below one-half (0.399 to 0.588, Regnault and Reiset).

During digestion the respiratory activity is increased, the amount of carbon dioxide approximating more closely to the amount of oxygen absorbed than when fasting. This is especially true if a vegetable diet is taken in which there is considerable starch. In fully-fed animals there appears to be also a slight excretion of nitrogen

through the lungs. In fasting animals nitrogen appears to be absorbed in small quantities in the lungs.

The respiratory activity is greater in children than in adults, in boys than in girls, in men than in women. The absolute amount increases with age and body weight in both sexes until puberty. In women it then remains nearly stationary (except during gestation, when it is greatly increased) until the cessation of the menses, when it increases for a few years. In men there is a gradual increase until the thirtieth or thirty-fifth year, then nearly a standstill until about the fiftieth year. Beyond fifty there is in both sexes a gradual decrease in the respiratory activity, following the decrease in general bodily activity.[6,14]

TABLE FROM SCHARLING [8] SHOWING THE VARIATION IN RESPIRATORY ACTIVITY IN PERSONS OF DIFFERENT AGE AND SEX.

Age and sex; weight in kilograms.	Carbon dioxide excreted in twenty four hours.	Carbon dioxide excreted per hour and kilogram.
	Grams.	Grams.
Man, age, 35 years; weight, 65.5 kilos.......	804.72	0.512
Soldier, age, 28 years; weight, 82 kilos	878 95	0.497
Boy, age, 16 years; weight 57.75 kilos	822.69	0 594
Woman, age, 19 years; weight, 55.75 kilos ..	608.22	0 455
Boy, age, 9¾ years; weight, 22 kilos	488 14	0.925
Girl, age, 10 years; weight, 23 kilos	459.87	0.833

Man and the other air-breathing animals have become so accustomed to the mixture of oxygen and nitrogen found constantly in the air, that this mixture is undoubtedly the best adapted for health and comfort; but owing to the fact that the absorption of oxygen and the excretion of carbon dioxide are regulated by the activity of the tissues, and that they are largely chemical processes, the respiration goes on practically unchanged in widely varying conditions of the atmosphere. In an atmosphere of pure oxygen the respiratory processes go on normally. If the amount of oxygen in the air falls considerably below the amount normally present, there is a feeling of distress, especially upon muscular activity, as the hæmoglobin cannot get the oxygen fast enough, owing to the low oxygen-tension in the air and its consequent slow absorption by the blood-plasma. Thus, in an atmosphere containing less than fourteen per cent. of oxygen dyspnœa occurs upon exertion; if it contains but seven per cent., breathing in repose is difficult; and if it falls to three or four per cent. there is rapid asphyxia, although there is no excess of carbon dioxide. The asphyxia produced by lack of oxygen is accompanied by violent spasms, while that resulting from an excess of carbon dioxide, when plenty of oxygen is present, is not usually accompanied by spasms.[6]

By a greatly diminished atmospheric pressure the respiratory gas-interchange is diminished in rapidity, and by an increased pressure it is increased. If the pressure of the atmosphere falls below two hundred and fifty millimetres of mercury warm-blooded animals soon die, owing in part to the slowness with which the oxygen comes into combining distance with the hæmoglobin, and, according to Hoppe-Seyler, in part to the liberation of bubbles of gas in the blood, and the consequent plugging of the blood-vessels. Under an increased atmospheric pressure the oxygen enters the blood-plasma more rapidly, and hence comes into combining distance with the hæmoglobin in such quantity that it may be fully saturated, and hence ready to supply the tissues more generously than under ordinary circumstances. If the pressure is too great (ordinary air at a pressure of fifteen atmospheres, pure oxygen under a pressure of three atmospheres) the animal dies of asphyxia, as if no oxygen were present. This is comparable with the non-combustibility of phosphorus in pure oxygen, and its ready combustibility when the oxygen is diluted with nitrogen, or if it is diminished in pressure.[6,8]

Variations in temperature have a marked effect in changing the respiratory activity. In cold-blooded animals the respiratory activity is in direct proportion to the rise in temperature up to the maximum not inimical to health. With the warm-blooded animals, in which the body temperature is maintained at a nearly uniform standard, the respiratory activity is lessened with an increase of temperature, and increased with a diminution of temperature.

WATER, ORGANIC MATTER, ETC., EXCRETED BY THE LUNGS.—Strictly considered, the excretion of water and other substances from the lungs may not properly belong to the subject of respiration; it is usually so included, however, as the excretion takes place from organs which are primarily organs of respiration, and it is a constant accompaniment of breathing. Under ordinary circumstances there is given off by the lungs about one litre of water in twenty-four hours. This water is derived from the mucous surface of the lungs and the air-passages. The amount of water required to saturate the breath with moisture depends largely upon the hygrometric conditions of the atmosphere. That is, if the air contains very little moisture a great deal must be added to it in the lungs to bring it to the point of saturation at the temperature of the body. On the other hand, if the air is warm and nearly saturated with aqueous vapor, only a little will be necessary to complete the saturation. If the air is warmer than the body, and saturated with moisture, it will be cooled in the lungs, and water will be deposited until the point of saturation at the lower temperature is reached. That is, the expired air may be cooler, and contain less watery vapor than the inspired air, but this is uncommon. Air containing considerable moisture is more comfortable to breathe than dry air. If it contains too much moisture there is produced a feeling of closeness, and if too little, the evaporation from the air-passages is so rapid that they become parched. For this reason it is more comfortable to sit in an artificially heated room in which watery vapor is constantly mixed with the heated air.

In addition to the watery vapor exhaled, there is constantly a small amount of organic matter given off with the breath. The exact nature and amount of this organic matter have not been determined, owing to the difficulty of so doing. It is this substance which produces the chief deleterious effects in breathing air over and over. The amount of carbon dioxide present in a room containing several individuals is usually not sufficient to produce any serious effects, as is shown by the continuous breathing of air containing a considerable amount of carbon dioxide by men when mining coal. The carbon-dioxide tension in the air of an inhabited room, however, is a good guide as to the wholesomeness of the air, for, if the carbon dioxide was produced in breathing, the air will also be loaded with the more dangerous organic matter, which cannot be so readily estimated. The lungs may also act as excretory organs in eliminating sulphuretted hydrogen and ammonia from the system, and also alcohol and various essential oils, like turpentine and those giving the odor to garlic, etc., which had been previously taken into the stomach.[5]

MECHANICS OF RESPIRATION.—Under this heading are included all the movements necessary for the supply of the respiratory organs with pure air and the removal of that which has become vitiated. For this respiratory ventilation, as it is often called, two very definite acts occur—*inspiration*, or breathing air into the lungs, and *expiration*, or breathing air out of the lungs.

Inspiration.—This is forcing air into the lungs, and is brought about entirely by muscular movement, as follows: The glottis is widely opened, rendering the passage to the lungs free; the diaphragm contracts, thereby flattening its arch and increasing the cavity of the thorax lengthwise (Fig. 3319). At the same time the muscles attached to the curved and sloping ribs contract, rotating and raising the ribs, and thus enlarging the thorax in its two transverse diameters (Fig. 3320). The enlargement of the thoracic cavity lessens the atmospheric pressure within it, and as there is no communication between the thoracic cavity and the air, the air rushes into the elastic lungs through the air-passages; the lungs stretch and completely fill the enlarged cavity in the thorax.

Expiration.—This is forcing the air out of the lungs.

In normal breathing it follows inspiration without a pause, and is brought about, in quiet breathing, by the relaxation of the inspiratory muscles, the weight of the elevated ribs and chest-walls, and the elasticity of the costal cartilages; by the elasticity of the abdominal walls and the abdominal organs; and, finally, by the elasticity of the lungs, which were put on the stretch during inspiration.

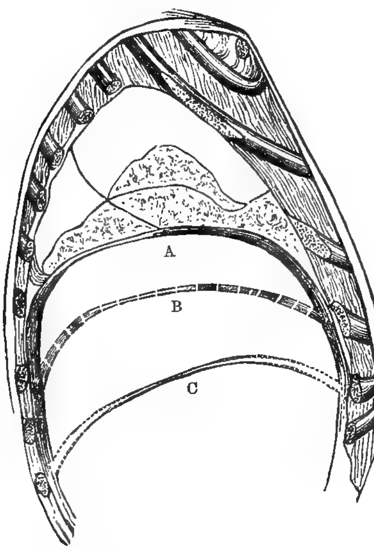

FIG. 3319.—View of the Thorax, with the left side removed to show the position of the diaphragm in various phases of inspiration and expiration. (Rosenthal.) A, position of the diaphragm in strong expiration; B, its position in moderate, and C, in deep inspiration.

Whenever, by any form of bodily activity or any other cause, the lungs cannot be thus sufficiently ventilated, the respiratory movements become more vigorous and the respiration is said to be labored. Whenever this occurs, muscles not employed in quiet inspiration are brought into action, and the expiration is no longer due to gravity and elasticity alone, but is aided by muscular contraction.

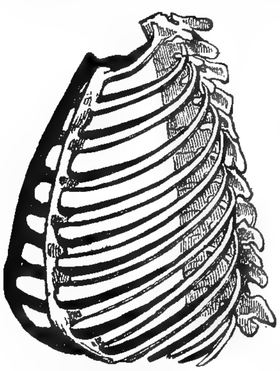

FIG. 3320.—View of the Left Side of the Skeleton of the Thorax, showing the position of the ribs and sternum in expiration (light shading) and in inspiration (dark shading). (Béclard.)

In the following list are given the muscles which aid directly in inspiration by making the thoracic cavity larger, or in expiration by diminishing that cavity; or they may aid indirectly by furnishing fixed supports for other muscles which can act directly on the thorax with more advantage thereby; or they may assist by opening more widely the air-passages. This list, which also gives the nerves supplying the muscles, is copied from Landois.[6]

Ordinary Inspiratory Muscles (the muscles in action during quiet breathing): The diaphragm (*nervus phrenicus*); the Mm. levatores costarum longi et breves (*Rami posteriores, Nn. dorsalium*); the Mm. intercostales externi et intercartilaginei (*Nn. intercostales*).

Auxiliary Inspiratory Muscles (muscles brought into action during labored and forced inspiration).

(A) The ordinary inspiratory muscles named above.

(B) *Muscles of the Trunk:* The three Mm. scaleni (*Rami musculares of the plexus cervicalis et brachialis*); M. sternocleidomastoideus (*Rami externus, N. accessorii*); M. trapezius (*R. externus, N. accessorii et Ram. musculares plexus cervicalis*); M. pectoralis minor (*Nn. thoracici anteriores*); M. serratus posticus superior (*N. dorsalis scapulæ*); Mm. rhomboidei (*N. dorsalis scapulæ*); Mm. extensores columnæ vertebralis (*Ram. posteriores nervorum dorsalium*); Mm. serratus anticus major? (*N. thoracicus longus*).

(C) *Muscles of the Larynx:* M. sternohyoideus (*Ram. descendens hypoglossi*); M. sternothyroideus (*Ram. descendens hypoglossi*); M. crico-arytenoideus posticus (*N. laryngeus inferior vagi*); M. thyreo-arytenoideus (*N. laryngeus inferior vagi*).

(D) *Muscles of the Face:* M. dilator narium anterior et posterior (*N. facialis*); M. levator alæ nasi (*N. facialis*); in gasping for breath the dilators of the mouth and nares.

(E) *Muscles of the Pharynx:* M. levator veli palatini (*N. facialis*); M. azygos uvulæ (*N. facialis*).

Muscles in Action during Labored Expiration: The abdominal muscles, including the obliquus externus and internus, and transversalis abdominis (*Nn. abdominis internis anteriores e nervis intercostalibus*, 8th to 12th); Mm. intercostales interni, so far as they lie between the osseous ribs,* and the infracostales (*Nn. intercostales*); M. triangularis sterni (*Nn. intercostales*); M. serratus posticus inferior (*Ram. externi nerv. dorsalium*); M. quadratus lumborum (*Ram. musculare e plexu lumbali*).

Rate of the Respiratory Movements, Apnœa.—According to the numerous observations of Hutchinson,[16] Sibson, and others, in quiet breathing there occur in the adult from eighteen to twenty inspirations and expirations per minute, or about one breath for every four heart-beats. The number of respirations, that is, the number of inspirations and expirations, is greater in children than in adults, and in those in the prime of life than in old age. In small animals, like the rat, the rate is far greater than in man (100 to 200 per minute), while in some at least of the larger animals it is slower than in man (rhinoceros, 6 per minute).[9]

Any circumstance increasing bodily activity in any form causes an increased rapidity of the respiratory movements to supply the extra oxygen demanded, and to remove the extra carbon dioxide formed. If the number and depth of the respirations are increased voluntarily, the total amount of oxygen absorbed and of carbon dioxide exhaled is not increased beyond what is due to the extra muscular exertion required in so breathing; for the respiratory gas-interchange is controlled entirely by the tissues, not by the respiratory movements. The expired air will, however, contain less carbon dioxide and more oxygen than usual, as the carbon dioxide excreted is more largely diluted by the extra amount of air, and the larger amount of air supplying a definite amount of oxygen is less impoverished than a smaller amount would be. If one breathes deeply and rapidly for a short time, it is easier to hold the breath for a considerable time afterward than when breathing ordinarily. Somewhat similarly, if artificial respiration be performed on an animal—a rabbit, for example—that has been in nowise injured, the animal will remain, for a considerable time after the artificial respiration has ceased, without breathing; the respiratory movements will then commence, and gradually increase in vigor until the animal breathes in a normal way as before the artificial respiration. It has been demonstrated, in one case at least, that a human being will show the same phenomena under the influence of artificial respiration after tracheotomy.[21] This cessation of breathing has been designated *apnœa* by Rosenthal.[18] It has received three explanations: (1) That of Rosenthal, who supposes that on account of the purity of the air in the lungs produced by the extra ventilation, the hæmoglobin of the blood becomes entirely saturated with oxygen, and this supply lasts for a considerable time before more is needed to keep the blood up to the ordinary standard of purity. (2) That of Gad,[6] who

* The controversy begun by Haller and Hamburger concerning the action of the internal intercostal muscles is still continued. At present, however, the majority of physiologists agree with Hamburger that the internal intercostal muscles between the bony part of the ribs act as expiratory muscles, while those between the costal cartilages act as inspiratory muscles.

supposes that on account of the purity of the air in the lungs the blood can get all the oxygen needed, and get rid of its carbon dioxide for a considerable time without further ventilation of the lungs. (3) That of Hoppe-Seyler,[13] who thinks the cessation of breathing is due to the exhaustion of the respiratory muscles. This view seems less satisfactory than either of the others, for in the case of the rabbits no muscular exertion was required on their part to exhaust their respiratory muscles, and furthermore, muscular activity tends to increase, not diminish, the rapidity of the respiratory movements.

Rhythm and Type of the Respiratory Movements.—In normal quiet breathing, beginning with inspiration, inspiratory movements are rapid and continuous, then expiration follows without a pause, but proceeds more slowly than inspiration, the ratio being, inspiration six, expiration seven, for adult men. In women, children, and the aged the ratio is, inspiration six, expiration eight or nine (Sibson). After expiration there is in many

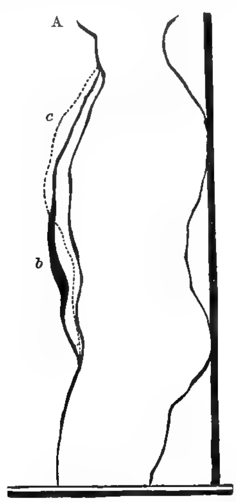

FIG. 3321.—Diagrams Showing the Change in Form of the Thorax and Abdomen during Respiration in the Male and the Female. (Hutchinson.) A, outlines of the male, and B, outlines of the female figure, indicating the different phases of the respiratory movements; *a*, *a*, outline of the body in full expiration; in this condition the lungs contain only the residual air. *b*, *b*, heavy continuous line; the outer margin indicates the contour of the body in ordinary inspiration, and the inner margin in ordinary expiration; the thickening of the line over the abdomen in the male, and over the thorax in the female, indicates that the greater movement occurs in the abdomen of the male (abdominal type of respiration), and in the thorax of the female (costal type of respiration); the entire thickness of the line represents the amount of tidal air; in ordinary inspiration the lungs contain the residual, the reserve, and the tidal air. *c*, *c*, dotted line giving the contour in the deepest inspiration; the thorax is greatly expanded, but the abdomen is less so than in ordinary expiration; in the deepest inspiration the lungs contain the residual, the reserve, the tidal, and the complemental air (see below).

cases a slight pause (expiration-pause) before the beginning of the following inspiration. This pause is not always present, and is always absent except in quiet breathing. The movements of a complete respiration are then, (1) a rapid continuous inspiration, (2) a somewhat slower expiration immediately following the inspiration, (3) in many cases a slight pause before the following inspiration.

The respiratory movements in some individuals are more especially due to the elevation of the ribs, and in others to the contraction of the diaphragm; consequently these movements have been divided into two corresponding types by Hutchinson,[16] viz., *costal respiration*, in which the enlargement of the chest is due largely to the elevation of the ribs, and *abdominal respiration*, in which the chest-cavity is enlarged most by the contraction of the diaphragm, with the consequent movements of the abdominal walls. The costal type is most common in women, the abdominal type in men. In children of both sexes there is no marked difference in type, and in the adult the differences are only noticeable in quiet breathing. In labored breathing the movements of the chest are most noticeable in both sexes (Fig. 3321).

Two explanations have been offered for the great prevalence of the costal type in the female: (1) That it is due to the habitual use of tight clothing around the waist; and (2) that it is a kind of reservation against the period of gestation. Hutchinson found the costal type marked in twenty-four girls, varying from eleven to fourteen years, who had never worn tight clothing around the waist.[16] On the other hand, Mays[22] found by careful experiments, made according to the graphic method, that in eighty-two North American Indian girls, varying from ten to twenty-two years, the abdominal type of breathing was marked in nearly every case. The experiments of Mays would indicate that the primitive and natural type of respiration in the female, as well as in the male, is the abdominal; but in comparing the observations of Mays and Hutchinson on subjects which had

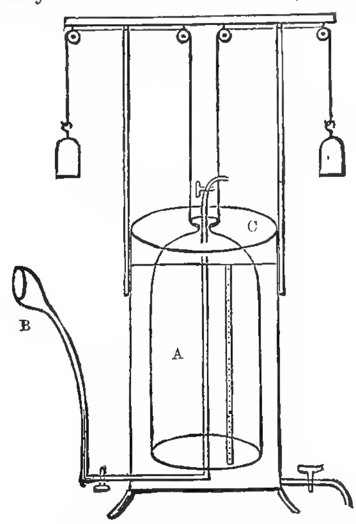

FIG. 3322.—Diagram of Hutchinson's Spirometer. (Landois.) A, graduated cylinder serving as a receiver for the breath; it is supplied with a stop-cock at the top for the ready expulsion of air, and is balanced by weights passing over pulleys. B, mouth-piece with tube reaching nearly to the top of the graduated receiver (A), when the latter is sunk in the reservoir ready for an experiment; there is a stop-cock in this tube near the first angle to prevent regurgitation of air. C, reservoir for the graduated receiver. In using the spirometer the reservoir and graduated receiver are filled with water, or, to prevent the absorption of carbon dioxide, with a saturated aqueous solution of common salt (NaCl.). When ready for an experiment, the stop-cock at the top of the receiver is closed and that in the tube of the mouth-piece opened, and the breath forced into the receiver. The receiver rises as fast as the breath displaces the water. After the breath is forced into the receiver the stop-cock in the tube of the mouth-piece is closed, and the water outside and inside the receiver brought to the same level, so that the air within the receiver shall be at the atmospheric pressure The amount of breath within the receiver is then read directly from the scale attached to the receiver. For accurate measurement the breath should stand a few minutes to acquire the temperature of the liquid over which it is collected, then the various corrections for aqueous vapor tension, and the variations from the standard temperature and pressure, should be made.

been equally free from the effects of tight clothing, it would appear that the type of respiration may differ in the females of different races.

Respiratory Ventilation.—In very young children the lungs are nearly emptied at each expiration, so that the ventilation is nearly complete; but after the first period of infancy a large amount of air remains constantly in the lungs, and only a limited amount of this is changed at each breath. Hutchinson and others have investigated with great assiduity the question as to the total capacity of the lungs, the amount of air in them under various conditions, the amount of air inspired and expired at each breath, etc. When the subject was first studied there were great hopes that it would give valuable aid in discovering and treating disease, but these anticipations were not realized. Its chief value is in hygiene; for, by

showing how much air is breathed by an individual in an hour, and knowing by analysis the contamination of the air due to being breathed once, data are furnished for the ventilation of rooms and buildings. For determining the various amounts of air expired under various conditions, Hutchinson [16] invented a kind of gasometer, called by him a *Spirometer* (Fig. 3322). In the following table is shown diagrammatically the relative position and amount of the different volumes of air that may be in the lungs at the same time.

Total capacity of the lungs, 5,300 c.c.	Breathing or vital capacity, 3,700 c.c.	Complemental air, 1,600 c.c.	
		Breathing or tidal air, 500 c.c.	
		Reserve air, 1,600 c.c.	Stationary air, 3,200 c.c.
	Residual air, 1,600 c.c.	"Collapse" air, 800 c.c.	
		"Minimal" air, 800 c.c.	

Complemental air is the amount of air that may be inspired after an ordinary inspiration.

Breathing or tidal air is the air inspired and expired at an ordinary breath.

Reserve air is that which may be expired after an ordinary expiration.

Residual air is that which cannot be expelled from the lungs by the most forcible expiration. It is composed of two nearly equal portions, the "*Collapse*" *air*, which escapes from the lungs when the chest is freely opened, and "*Minimal*" *air*, that which remains in the lungs after the thorax is opened.

Breathing or vital capacity. This is the amount of air which may be forced from the lungs after the deepest possible inspiration. It is the sum of the reserve, the tidal, and the complemental air.

Stationary air. This is the sum of the reserve and the residual air, and is so named as, under ordinary circumstances, these two volumes of air remain constantly in the lungs.

Many experiments have been tried to determine the amount of change of the air in the lungs by a single breath. From the nature of the problem no method is wholly satisfactory. The one originally proposed by Davy is most used. It consists of inhaling a known volume of pure hydrogen, and then analyzing the expired air. If no mixing of the hydrogen with the air already in the lungs takes place, then the expired gas, like the inspired, would be pure hydrogen. By actual experiment it is found that, supposing 500 c.c. of pure hydrogen are inhaled, only 170 c.c. of hydrogen are exhaled, the remaining 330 c.c. being air. That is, 330 c.c. of the inhaled hydrogen displace the same amount of air. If, now, it is assumed that in ordinary breathing 500 c.c. of air are inhaled, and the 330 c.c. of this remain as with the hydrogen, and displace a similar amount of vitiated air, then the amount of renewal must be the ratio between the air in the lungs before the inspiration—that is, the reserve and the residual air (3,200 c.c.), and the fresh air (330 c.c.) remaining in the lungs after each expiration—$\frac{330}{3200} = 0.103$. This has been termed the coefficient of ventilation,[8] and in the case given shows that only about one-tenth of the air in the lungs is changed at each breath. The intermixture of this fresh tidal air with the reserve air in the air-passages is due largely to the currents produced by inspiration, but the residual air in the alveoli and smallest air-passages must depend mostly on diffusion for its purification. This diffusion is no doubt greatly facilitated by the swaying to and fro of the air as the chest alternately expands and contracts, to the jars produced by the heart-beats and the pulsation of the pulmonary arterioles, and also to the ciliary currents in the bronchi. It would seem reasonable to suppose, therefore, that the air in the alveoli remains of a nearly uniform quality, and that it contains a greater percentage of carbon dioxide, and a less percentage of oxygen than the expired air. The direct experiments of Wolfberg and others, however, show that there is but little difference in the composition of the alveolar air and that which may be expired by a full expiration. This seems to show that the diffusion in the lungs is very rapid.[8]

Pressure in the Air-passages.—This varies in inspiration and expiration. It is measured by connecting a manometer with the nose or mouth, or, in an animal, with the trachea, and noting the variations in the columns of mercury during inspiration and expiration. In man, when there is a perfectly free entrance for the air to the lungs, the aspiration, suction, or negative pressure during quiet inspiration is about 3 mm. of mercury, and during expiration the positive pressure is from 2 to 3 mm. In forced inspiration the aspiration may reach 57 mm. hg., and in forced expiration the pressure may rise to 87 mm. hg. If the air-passages are closed, so that no air can enter or leave the lungs, then the aspiration or negative pressure is from 30 to 74 mm. hg., when inspiratory efforts are made; and when expiratory efforts are made the pressure is 62 to 100 mm. hg.

The elastic lungs are during life and the complete integrity of the thorax somewhat stretched. If the trachea of a dead person is connected with a manometer and then the thorax freely opened, the elasticity of the lungs will show a pressure of 6 mm. hg. If the lungs are fully inflated, then the pressure due to their elasticity will be measured by about 30 mm. hg. This shows very graphically the part played by the elasticity of the lungs in expiration.[6,12]

The respiratory sounds and the interaction of the circulatory and respiratory movements have already been treated in this HANDBOOK, the first under Chest, vol. ii., p. 82; the second under Blood-circulation,[17] vol. i., pp. 563, 566.

The Respiratory Centre and the Nerves of the Respiratory Apparatus.—As with all the other muscles and organs of the body those belonging to the respiratory apparatus are well supplied with nerves. The names of the nerves supplying the respiratory muscles are given above in the list of the muscles. It has further been found that the whole complex mechanism of respiration is under the control of a nerve-centre, termed from its office *the respiratory centre;* and from the fact that an animal invariably dies after its destruction, it is called the vital point (*nœud vital*). This centre is situated in the medulla, near the origin of the vagus nerve. While it has been known from the time of Le Gallois [18] that this centre exists in the medulla, the question whether it is a reflex centre, acting only in accordance with afferent impulses from without, either through special nerves like the vagus, or through those from the entire system, or whether it is an automatic centre acting in accordance with changes going on within itself, was for a long time unknown. It is now quite well established that the centre is automatic, although its action may be greatly modified by afferent impulses. It is a matter of common experience that one can cease breathing for a limited time, or can greatly increase the number and depth of the respirations, at will; also that a dash of cold water causes most persons to take a deep breath, and by the application of snuff or dust to the nose a sneeze is produced. So coughing, which is likewise only a modified respiratory act, is induced by an irritation of the glottis, etc. While, therefore, the centre is constantly being influenced from without, the final proof of its automatic action is given by the following experiments:

In 1879 Flint[5] showed that if the thorax of an animal is opened and artificial respiration kept up sufficiently to aerate the blood well, no respiratory efforts are made by the animal; but if the vessels going to the medulla are clamped, cutting off the supply of arterial blood to the respiratory centre, violent respiratory movements are made, although all the rest of the body is well supplied with arterial blood. On the other hand, if clamps are put on the vessels so that oxygenated blood can go only to the respiratory centre, no respiratory movements will be made, although all the rest of the body is suffocating.

Anatomically and physiologically, the respiratory cen-

tr[illegible] is symmetrical, there being one on each side, as is shown by the continuance of the respiratory movements after cutting the medulla longitudinally. If one side of the centre is then destroyed the respiratory movements cease on that side, but continue on the other. There are also many reasons for supposing that the respiratory centre is composed of an inspiratory and an expiratory part, the expiratory part being cephalad, or in front of the inspiratory part.[6, 18]

The stimulus acting on the respiratory centre to arouse its activity seems to be the blood which circulates in it. If this blood contains too small an amount of oxygen the centre sends out stimuli to the inspiratory muscles, and then, slightly later, to the expiratory muscles. An excess of carbon dioxide seems also to have a stimulating effect on the respiratory centre, chiefly the expiratory part (Bernstein).[10] The lack of oxygen is the more potent factor in arousing the respiratory centre, however, as is shown by the fact that the most violent respiratory efforts are made when a deficient supply of oxygen is present in the air supplied to the lungs, although there may be no excess of carbon dioxide. If there is plenty of oxygen in the air, and an excess of carbon dioxide, the animal often dies from carbon-dioxide poisoning, without spasms.

Besides the main respiratory centre in the medulla, other centres, called accessary respiratory centres, have been described as present in the myel or spinal cord, and also in the brain; but at present exact information concerning these centres, if they exist, is very meagre.[6]

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Simon H. Gage.

RHATANY (*Krameria*, U. S. Ph.; *Krameriæ Radix*, Br. Ph.; *Radix Rhataniæ*, Ph. G.; *Ratanhia*, Codex Med.). The roots of some species of *Krameria*, especially *K. triandra* Ruiz and Pavon, and *K. Ixina* Linn. (*K. tomentosa* St. Hilaire), order *Polygalaceæ* (*Leguminosæ*, *Krameriæ*, Luerssen).

FIG. 3323.—Krameria Triandra; flowering branch. (Baillon.)

Krameria triandra is a low shrub with a thick, dark-colored, woody, branching root, and straggling, slender, branching stems. These latter are from one-third to one metre in length, the longer reclining or horizontal, the shorter erect; bark grayish-brown, twigs greenish-gray, silky. Leaves alternate, sessile, obovate, lanceolate, spiculate, silky-hairy. Flowers solitary, axillary near the ends of the branches, calyx of four scarlet sepals, cruciform, the lateral sepals shorter than the others. Petals four, also scarlet, the two upper erect, spatulate, the two lower short, broad, and glandular. Stamens three, short and thick. Pistil simple; ovules two. Fruit spherical, silky, and spiny. This species is indigenous to high, sandy slopes in Peru and Bolivia, and is the source of the Red Peruvian Rhatany.

K. Ixina has a larger, smoother, more brown or purplish root, longer leaves, smaller and duller-colored flowers, and five sepals. It grows in the West Indies, and in Central and South America. Its root, which is fully as good as the other, is known as Savanilla, New Granada, or Violet Rhatany. There is very good reason for placing this anomalous genus near the sub-order *Cæsalpinæ* in Leguminosæ.

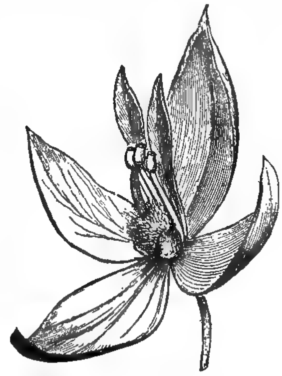

FIG. 3324.—Krameria Triandra; flower. (Baillon.)

Rhatany root was noticed by Ruiz in 1784, as used by the women of Huanaco and Lima for the preservation of their teeth, and by him was introduced into Spain a year or two after (Flückiger), whence it soon became known.

Peruvian Rhatany (root) "is about one inch thick, knotty and several-headed above, branched below, the branches long, bark smooth or scaly, deep rust-brown, about one-twelfth of an inch (2 millimetres) thick, very astringent, inodorous; wood pale-brownish, tough, with fine medullary rays, nearly tasteless. The root of *Krameria tomentosa* (Savanilla Rhatany) is less knotty and more slender, and has a dark purplish-brown bark about one-eighth of an inch (3 millimetres) thick.

Both varieties have essentially the same medicinal

properties and composition. The most important constituent (of the bark—the wood is nearly inert) is *Rhatania-tannic acid*, existing to the extent of about twenty per cent.; a brilliant, deep-red, amorphous mass, soluble in alcohol, incompletely so in water; with perchloride

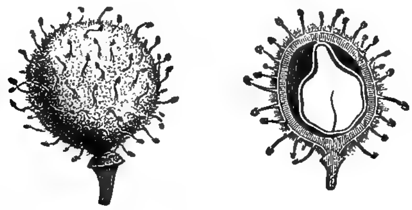

FIG. 3325.—Krameria Triandra; fruit, entire and in section. (Baillon.)

of iron it gives a dull-green color. When exposed to the action of diluted acids, and under other circumstances, this tannin is decomposed into sugar and *Rhatania red.* This substance is much less soluble in water than the tannin, and is also but little soluble in alcohol and ether.

ACTION AND USE.—Rhatany is a reliable and useful astringent, owing to its large per cent. of tannin, and is

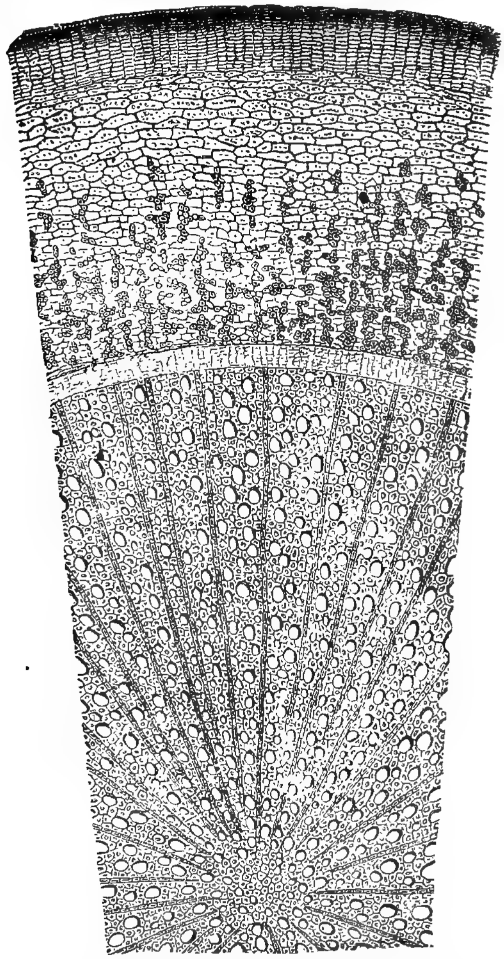

FIG. 3326.—Krameria Triandra; transverse section of root. (Baillon.)

applicable to all the conditions where gallic or tannic acid is useful. The crude drug may be given in powder, but seldom is, as the large amount of woody tissue is a disadvantage. Dose, one or two grams (gr. xv. ad xxx.). The following officinal preparations are all good: Extract (*Extractum Krameriæ*) for pills, strength about $\frac{4}{1}$; Fluid Extract (*Extractum Krameriæ fluidum*), strength $\frac{1}{1}$; and Tincture (*Tinctura Krameriæ*), strength $\frac{1}{5}$.

ALLIED PLANTS.—There are a dozen or more South American species of Krameria, all astringent, and several are in use in the countries where they grow.

ALLIED DRUGS.—See NUTGALLS, CATECHU, etc.

W. P. Bolles.

RHEUMATISM, ACUTE ARTICULAR. *Synonyms:* Rheumatic Fever, Acute Rheumatism, Acute Rheumatic Polyarthritis.

Definition.—Acute articular rheumatism is a specific inflammation which attacks the structures in and around the large joints. As a rule, two or more articulations are affected, and the inflammation moves from one to another. It is scarcely ever followed by suppuration. It is accompanied by severe febrile disturbance. In a large proportion of cases the fibro-serous structures of and about the heart are also affected by the inflammatory process.

History.—This disease has doubtless existed from the earliest ages, but the term rheumatism was first applied to it by M. Baillon, who published a treatise on the subject in 1642. The term was afterward applied by many authors to inflammation of the joints generally. We now distinguish under several heads diseases which formerly, by some, were called rheumatic, viz.: 1, Articular rheumatism; 2, gout; 3, rheumatoid arthritis; 4, muscular, and 5, gonorrhœal, rheumatism.

Articular rheumatism may conveniently be divided into (*a*) acute, (*b*) subacute, and (*c*) chronic forms.

Morbid Anatomy.—Opportunities for making post-mortem examinations in cases of acute rheumatism are rare. The synovial membrane is found congested, the inner surface being rather dull in appearance, with a serous fluid filling the cavity of the joint. This fluid contains masses of epithelium. Occasionally pus is found in the exudation. The structures around the joint are also inflamed. Sometimes the tendinous structures are filled with a yellowish serum. The cartilage often shows signs of inflammation.

Symptoms.—The onset of the disease is marked by different features in different cases. The attack is sometimes preceded by a slight chill followed by fever. In many cases there is a premonitory stage, during which wandering pains occur in the joints, and there is observed a peculiar puffy condition about the ankles. In a few instances the pericardium or endocardium is first attacked. In such cases the patient first notices a sense of oppression, with dull pain, in the chest. When the disease has become established the most prominent symptoms are as follows: Pain and swelling of the larger joints of the body; elevation of temperature with general febrile disturbance; the occurrence of excessive perspiration. The joints most often affected are the knee, elbow, wrist, and the smaller joints of the hands and feet. The hip and shoulder may also be attacked, but the swelling is less apparent in these, owing to their being covered by large muscles. The swelling is often accompanied by some redness and tension. Neither of these latter symptoms is as prominent as in gout. The pain is more or less acute; it is sometimes dull and aching, but more frequently it is severe and excruciating. It is increased by the slightest movement; even the shaking of the bed will make it more intense. The patient is thus rendered quite helpless, and speaks of having lost the use of his limbs. The pain is more severe at night than during the day. The swelling of the joints varies very much in different cases. In some it is but slightly marked, and is not accompanied by much redness, or tenderness on pressure. In others, again, the swelling is excessive, so that the articulation presents a red, shining, tense appearance, very much resembling gout except that the surrounding veins are not enlarged. It is remarkable how quickly the swelling may subside. A joint may present the most severe symptoms on one day, and the next it may have almost resumed its normal condition. The intense inflammation usually lasts four or five days, and on its disappearance other articulations may become affected.

The same joint may be attacked two or three times during the illness. The inflammation passes from one joint to another so rapidly that some have considered it an example of metastasis. As a rule, however, the second series of joints are attacked before the first are entirely normal. Pitting on pressure occurs in some delicate patients. Suppuration is a very rare sequence in rheumatism.

The presence of excessive perspirations is a very frequent symptom. They occur in exacerbations, when the sweat often possesses a peculiar, sour odor. This is due to the presence of an acrid substance rather than to excess of lactic acid. A red, papular eruption, together with sudamina, frequently appears on the skin, the result of profuse sweating.

A peculiar erythematous eruption, peliosis rheumatica, has been noticed in some cases of acute rheumatism. The rash does not differ from erythema multiforme, as we now use that term. Urticaria is present in some cases. The temperature during an attack rises to 102° or 104° F.; in some cases of hyperpyrexia it rises to 110° F. The fever is of a remittent rather than a continuous character. The temperature is usually higher in proportion to the number of joints attacked. The tongue is coated thickly with a white fur. The saliva, which is normally alkaline, becomes acid. There is loss of appetite with more or less nausea. The bowels are constipated. The urine is scanty, high-colored, and strongly acid in reaction; its specific gravity is higher, owing to increased quantity of urates and urea; on standing a reddish sediment is formed. Albumen is sometimes found in small quantity during the febrile stage and during convalescence. The pulse is increased in frequency, often out of proportion to the rise in temperature. This may be due to severe pain or to the onset of cardiac trouble. The respirations are frequent and often shallow. They become greatly hurried when there are severe heart-complications. The red corpuscles of the blood are much decreased in number, and the amount of fibrin is increased.

In a large proportion of cases, the fibro-serous structure of the heart is attacked. The endocardium is much more frequently affected than the pericardium, the proportion being as six to one. In a few cases the muscular wall is also involved. The structures are attacked in the same way as the joints, the result of the elective affinity of the poison. Their involvement is not an instance of metastasis, nor should it be regarded as a complication, but simply as a part, of the disease. Rheumatic inflammation of these structures differs from that of the joints in two or three particulars. The exudation contains lymph, often becomes organized, and occasionally degenerates into pus. Pericarditis is usually accompanied by a dull pain beneath the sternum and a sense of oppression in the chest. By auscultation a friction-sound can be heard most distinctly over the base of the heart. This soon disappears as the serum accumulates in the pericardial sac. The presence of the latter is diagnosed by the increased cardiac dulness and diminished cardiac impulse. The endocardial inflammation is confined almost altogether to the left side of the heart. Its presence is usually made known by abnormal valvular murmurs, which are heard on auscultation. It may here be stated that one often hears abnormal heart-murmurs, during an attack of rheumatism, which disappear in a few days. In some of these cases it is difficult to say whether endocarditis was present or not. Two theories have been given to explain such cases: First, that there is a temporary dilatation of the heart; second, that an endocarditis may exist which undergoes rapid resolution. For further details, see vol. iii., pp. 583 and 584; and vol. v., p. 573 et seq.

The duration of acute rheumatism varies much—it may disappear in five or six days, or it may last as many weeks. The average duration is from two to three weeks. The patient is scarcely ever free from pain and fever during this period, and there are frequently exacerbations, which are followed by periods of comparative relief. There is a strong tendency to relapse, and many patients are subject to repeated attacks of the disease.

Unusual Events and Complications in the Course of Acute Rheumatism.—A frequent complication is pleurisy of the left side, which is said to occur in ten per cent. of all cases in which the heart is involved. Bronchitis, congestion, œdema of the lungs, and catarrhal pneumonia are sometimes concurrent with acute rheumatism. In rare cases inflammation of the meninges of the cord and brain complicates the disease.

Delirium, convulsions, and coma have been recorded. Chorea sometimes follows rheumatism in children. Acute delirium occurs in cases of hyperpyrexia. Organic changes of the nerve-centres from embolism are among the possibilities. A few singular cases of rheumatic hyperpyrexia have been recorded by Ringer, Maclagan, and others. In these the temperature rises sometimes to 110°. They are marked by the presence of acute delirium, which rapidly passes into coma; such cases are very frequently fatal. They often commence and continue for a few days in the ordinary way, when suddenly the temperature rises and the patient becomes delirious. It has been found necessary to reduce the temperature by the application of ice, and some cases have been saved in that way. It is probable that the excessively high temperature is due to impairment of the heat-centre in the bulb, and the brain-symptoms result from the effect of heat upon the nerve-substance.

Subacute Rheumatism.—Under this head cases have been described in which only two or three of the joints are affected at one time, and the pyrexia is of a mild type, the temperature not rising above 100° F. The duration is usually much longer than in the acute cases, but the joints are not permanently affected and serious heart-trouble does not follow. This subacute variety forms a connecting link between the acute and chronic forms. In a few cases the disease, after attacking two or three joints, finally settles in one articulation. This is usually the case in the gonorrhœal form, but it also occurs sometimes in the acute and subacute varieties.

Etiology.—Exposure to dampness and cold has generally been considered the principal factor in the causation of rheumatism. Severe muscular exertion, attended by overheating of the system and followed by chilling of the surface, is a frequent cause. Neither of these will produce rheumatism unless the patient is predisposed to the disease, either from hereditary or acquired taint. An hereditary predisposition, according to Fuller, is present in thirty-four per cent. of all cases. A long residence in a damp and cold climate seems to render the system liable to an attack. Age has a strong influence in predisposing to rheumatism. It does not often attack children under fifteen years of age, nor adults over forty-five. One is more subject to it between the ages of fifteen and thirty than at any other time of life. The heart is not often attacked after forty years of age. The same person may suffer from several attacks. The number of males affected is somewhat larger than the number of females. The former are more exposed and more frequently engaged in severe muscular exercise. Season and climate exert a predisposing influence. It is most prevalent in the cold, moist climate of the temperate zone. On this continent most cases occur in the latter part of the winter or early spring. Occupations which require great muscular effort in a warm atmosphere predispose to rheumatism. Washerwomen, bakers, maid-servants, moulders, and laborers generally are among those especially liable to the disease. Diet probably exerts some influence; the ingestion of an excessive amount of saccharine and starchy food increases the tendency to this malady. Certain diseases appear to have an etiological relationship. In the desquamative stage of scarlet fever, a mild form of articular inflammation sometimes presents itself. In dengue, hæmophilia, gonorrhœa, and in the puerperal state, a special tendency to inflammation of the joints appears to be present. In some of these latter diseases the polyarthritis is often of a pyæmic form.

Pathology.—Rheumatism must be considered as a general disease with local manifestations. The febrile condition appears to be a primary rather than a secondary element in the process. The inflammatory condition is

of a special character, and is the result of a materies morbi existing in the blood. It has a tendency to attack the fibro-serous structures connected with the locomotor apparatus and with the heart—in other words, those structures subject to movement and strain. As to the nature of the materies morbi, there has been much difference of opinion. According to Prout's theory, laçtic acid is the foreign constituent of the blood which causes the local inflammation. The arguments in favor of this view may be briefly stated as follows: First, that in acute rheumatism we always have an excess of the acid; second, that in some cases of diabetes, where lactic acid had been given for a few weeks, symptoms of rheumatism were developed; third, that the injection of lactic acid into the blood of lower animals has resulted in the production of endocarditis. The malarial theory has been strongly advocated by Dr. MacLagan. He is of the opinion that the excess of lactic acid is the result rather than the cause of the rheumatic process, and that the essential cause of the disease is a miasm which enters the system from without. He finds strong confirmation of his theory in comparing rheumatism with remittent and intermittent fever. According to this view, the salicylates act by destroying the malarial poison, and thus check the disease at its commencement.

Hueter is of the opinion that the micrococci pass into the blood through the sweat-glands, and first set up endocarditis. From this source emboli pass into the general circulation.

The nerve theory, which was first promulgated by Dr. I. K. Mitchell, and afterward supported by such eminent clinical authorities as Gull, Weir Mitchell, Charcot, and Jonathan Hutchinson, has received much attention. According to this theory the exciting causes, cold or dampness, produce an impression on the surface of the body which is conducted to the vaso-motor and trophic centres by the afferent nerves. The joints and other structures become affected through these systems. One would suppose, if this were the correct view, that the disease would come on much more quickly after exposure than is really the case. By combining these various theories we may, perhaps, arrive at a fairly correct view of the nature of rheumatism. This special form of inflammation is the result of the presence of abnormal products in the blood, of which lactic acid appears to be the most prominent. Their existence may be due to several causes. One of these may be the entrance into the blood of a special micro-organism, as taught by Recklinghausen and Klebs. Another cause may be an hereditary condition of the system, in which there is deficient power of assimilation. Prolonged exposure to a damp, cold atmosphere may produce the same result. It is a singular fact that prolonged and severe muscular exertion should so often light up the disease. In such cases it is probable that, previous to the exertion, the system contained all the abnormal products possible, and that the sarco-lactic acid evolved during exertion was just sufficient to turn the scale.

Prognosis.—The prognosis of rheumatism is favorable, so far as the immediate result is concerned. Death rarely takes place during the acute attack, unless there are serious complications. The pathological changes which sometimes take place in the heart structures are often the cause of death at a later period. When a case of acute rheumatism terminates fatally, it is usually the result of severe heart trouble. In such cases the cardiac walls are often affected. The prognosis is also favorable, so far as the joints are concerned. Permanent changes in the articulations are rare, unless the disease becomes chronic.

Treatment.—The therapeutics of rheumatism is still in an unsatisfactory state, as may be inferred from the number of remedies recommended. For years the alkaline treatment, as taught by Fuller, was very largely adopted. According to this method the bicarbonate of potash or soda was given in large and frequently repeated doses, until the urine became alkaline or neutral in reaction. This can be accomplished in from twelve to twenty-four hours. Fuller gave sodium bicarbonate, one and a half drachm; potassium acetate, one-half drachm, in three ounces of water, to which half a drachm of citric acid was added just before administration. This dose was repeated every three or four hours until the urine became alkaline. As a rule, in general practice the alkalies are not given in such large doses, nor so frequently repeated. This may explain, as Dr. Howard suggests, the difference in the recorded results. The theory upon which this treatment is based is, that by the administration of alkalies we counteract the acid condition of the blood and of the secretions. It has been proved that by this method we are enabled to mitigate the severe pain of rheumatism, but it is doubtful if by it the duration of the disease has been shortened or heart complication prevented. Drs. Gull and Rees published a number of cases, thirty-five in all, in which the expectant plan had been adopted. No specific remedy was administered. The average duration of the acute symptoms, when the heart was not involved, was a little over eight days; when the heart was affected, the duration was about twenty-two days.

Other remedies, such as quinine, tincture of iron, colchicum, propylamine, and lemon-juice have been recommended from time to time.

Salicin.—Dr. MacLagan, in 1876, published, in the London *Lancet*, his experience in the administration of salicin in acute rheumatism. He commenced to use it in 1874, and was so struck with the decidedly good results obtained that he spoke of the remedy with great confidence.

About the same time Kolbe, in Germany, discovered a method of obtaining salicylic acid from carbolic acid. This drug was used in rheumatism by Stricker and Riess with much success. An account of their experience was published in the early part of 1876. The appearance of these papers marked an era in the treatment of rheumatism. Salicin and the salicylates have since been largely employed, and we are now in a fair position to judge of the results. The latter may be epitomized as follows: (1) The salicyl compounds have a decided action in mitigating the severe symptoms when they are administered early and in frequently repeated doses; (2) the average duration of the disease has been shortened by these remedies; (3) they do not prevent heart complication; (4) relapses occur more frequently when the salicyl treatment has been used. It has also been asserted that patients do not rally so quickly after they have taken these drugs. Dr. MacLagan recommended salicin to be given in from twenty to forty grain doses every hour at the commencement of the attack.' Salicylic acid may be administered in twenty-grain doses every hour until the urgent symptoms are relieved. It is now usually given in combination with soda, in the form of sodium salicylate. It is necessary to continue the salicylate during convalescence to prevent relapses. One great drawback to the use of the salicylates is their irritant action on the stomach. This is much relieved when a simple solution is taken in aerated water. Weakness of the heart's action has been noticed after large and repeated doses. This has been so marked in some cases as to require the use of stimulants. A buzzing sound in the ears and temporary deafness are almost universally experienced after the use of the salicyl compounds. Dr. Howard, of Montreal, recommends the administration of citrate of potassium in combination with sodium salicylate. He also recommends benzoate of ammonia in cases where the salicyl compounds have failed. Latham recommends the salicylic acid made from salicin as a better preparation than that made from carbolic acid. Oil of gaultheria has been recommended by Dr. Kinnicutt, of New York, who used it in a number of cases instead of sodium salicylate. It is composed of ninety per cent. of methyl salicylate, and ten per cent. of terebine. Ten to fifteen minims are given floating on milk, or dropped on loaf-sugar. The effects are very similar to those of the other salicyl compounds. In the later stages quinine is indicated in moderate doses. Dr. Bartholow gives the following excellent rules for treatment. He divides cases of acute rheumatism into three classes: (1) In fleshy persons, those, for instance,

who drink beer to excess, the disease is generally subacute and lengthened in character. In these, alkaline treatment, as given by Fuller, is of the most service. (2) In ordinary cases of the acute disease in a previously healthy subject the salicyl compounds are the proper remedies. (3) In anæmic cases tincture of iron in large and repeated doses will have the best effect. In these latter cases the salicyl compounds are more likely to produce weakness of the heart's action than in strong persons.

Local Treatment.—Wrapping the affected joints in cotton batting is usually the only local treatment adopted. Dr. Herbert Davies, of London, recommends the application of blisters over the swollen articulations. These seemed to reduce rapidly the local inflammation, but the frequent production of strangury was a decided drawback to the treatment. Tincture of iodine has been recommended as a local application. Belladonna liniment with a solution of opium is often of service in relieving pain. Fuller's lotion consists of Battley's solution of opium (an English preparation), ℥ j.; potassium carbonate, ℥ ss.; glycerine, ℥ ij.; water, ℥ vj. It may be freely applied. As rheumatism is a general rather than a local disease, its successful treatment will depend rather on internal than external remedies.

General Measures.—The patient should be placed in a well-ventilated room. The temperature should be moderate and constant. The clothing ought not to be so heavy as to increase the perspiration. The body should be frequently rubbed with a dry towel, so as to remove the excessive perspiration. A light, unstimulating diet is the safest during the acute stage. Tonics and good diet are indicated in the stage of convalescence. Stimulants are rarely needed. *James E. Graham.*

RHEUMATISM, CHRONIC ARTICULAR. Syn.: Arthritis Rheumatica Chronica, Rheumarthritis Chronica. Chronic articular rheumatism is a mild but persistent inflammation affecting the ligaments, synovial membranes, cartilages, and sometimes the capsules of the joints. It may be limited to any one of these structures, or it may pervade them all at the same time. It may be limited to the structures of a single articulation, but more frequently it affects several simultaneously or in quick succession, more especially the smaller joints of the extremities.

Morbid Anatomy.—The morbid actions constituting chronic rheumatism, affecting the fibrous structures connected with the articulations, pretty uniformly induce more or less plastic exudation or proliferation and thickening of the parts, but with no tendency to purulent degeneration or formation of pus. In cases of long standing the thickened and dense ligaments often coalesce with the softer tissues; the villi in the interior of the joints become hypertrophied, and the cartilages become uneven and undergo some fatty changes, causing the whole joint to appear enlarged, altered in shape, and much less movable than natural. When the synovial membranes are involved, a small quantity of turbid serous fluid is often found in them, which is generally much increased temporarily by occasional subacute attacks, to which such cases are very liable from sudden and severe atmospheric changes.

Etiology.—Chronic articular rheumatism is often the sequel of more acute attacks; but many cases are chronic *ab initio*, and are of particularly frequent occurrence in cold, damp, and variable climates, and among such adults as are much exposed to cold and wet in connection with severe physical exercise. Living or working in cold and damp rooms or workshops, or standing with the feet and hands much in water, actively dispose to attacks of chronic rheumatism, more especially in the smaller articulations of the upper and lower extremities, and in the lumbar region of the spine. Consequently, washerwomen, housemaids who do much scrubbing, and coachmen or those who wash carriages, are particularly liable to this form of disease. But cases are occasionally met with in all classes, and in those engaged in any of the various occupations, although the disease occurs very rarely in childhood or youth.

Symptoms.—When chronic articular rheumatism is the sequel of acute attacks, the affected joints remain slightly swollen, with stiffness and some soreness on motion, which is usually diminished by continuous moderate exercise, but returns again after a few hours of rest. There is no redness of the surface nor increased heat, and generally but slight tenderness to the touch, except when the disease is aggravated by the supervention of more acute symptoms from fresh exposure to the primary causes. At such times the dull, aching pain is increased, especially during the night; there are moderate general febrile symptoms, and some serous effusion into such synovial sacs as are involved in the inflammation. In a few days these more active symptoms subside, leaving only the usual local stiffness and dull pains that belong to all cases of chronic rheumatism, whether preceded by acute attacks or not. In nearly all cases the pain in the affected part increases during the middle and latter part of the night, and is less during the day. Still more marked increase of the pains accompanies almost every change in the atmosphere in the direction of cold and wet. So true is this that many rheumatic patients detect the developing atmospheric changes earlier than are indicated by either barometer or thermometer. In some rare cases, in which the ligaments and tendons become not only indurated but closely adherent to their sheaths and to the soft parts surrounding them, all motion is interrupted, constituting a form of anchylosis.

A few cases of this kind have come under my observation, in which the knees, ankles, and smaller joints of the feet, together with the elbows, wrists, and articulations of the hands and fingers had become fixed at different degrees of flexion, thereby rendering the patients unable to get either the hand to the head or both feet on the floor at the same time. The most common and constant symptoms of chronic articular rheumatism are dull pains in the affected parts during the night, especially during the transition seasons, when frequent atmospheric changes occur; and stiffness with some pain on rising from the bed in the morning, which diminishes or disappears by moderate exercise during the morning hours.

In a large proportion of cases the general health of the patient is good, and all the important functions are performed with regularity. In many, however, the skin is more dry, the urine is scanty and high-colored, the bowels are habitually costive, and there are acid eructations or flatulency.

Diagnosis.—To distinguish chronic rheumatic arthritis from traumatic, scrofulous, or nervous affections of the joints, is not generally difficult. The dull character of the pain, its proneness to increase at night, and to be greatly influenced by atmospheric changes; the greater stiffness and soreness on motion after rest, diminishing with exercise; the middle or advanced period of life, and the entire absence of any tendency to suppuration, are so characteristic of chronic rheumatism, and so nearly the reverse of what occurs in the history of other affections of the joints, that few mistakes need be made unless through carelessness or want of attention to all the facts and circumstances of each case.

Prognosis.—This, so far as relates to the continuance of life, is always favorable in this disease, but almost equally unfavorable so far as regards complete and permanent recovery. In some comparatively recent cases I have seen permanent recoveries, usually, however, in consequence of removal to a more favorable climate; and, in a large majority of cases, much relief or mitigation of the disease has been obtained by proper and persistent attention to such prophylactic measures as are available.

Treatment.—As just intimated, the successful management of cases of well-established chronic rheumatic arthritis is a task of great difficulty. This is owing largely to the fact that much the larger number of these cases occur among the laboring classes, and in individuals who can neither afford to separate themselves from further exposure to the predisposing and exciting causes of the disease, nor be induced to adopt such measures, habitually, as would best protect them from the effects of the further exposures. These patients gener-

ally call for the aid of their physician only when they are suffering from an exacerbation of their symptoms, and cease to heed his directions as soon as the more active symptoms have subsided. When called to such cases, I have found no remedies for internal use more beneficial than the salicylate of sodium, or acetate of potassium, in solution with either the fluid extract or tincture of phytolacca decandra, cimicifuga racemosa, or senecio aureus and stramonium. The following is a convenient and efficient formula:

℞. Salicylate of sodium...25 grams = ʒ vj.
Fl. ext. phytolacca dec....60 c.c. = ℥ ij.
Tinct. of stramonium.....15 c.c. = ʒ iv.
Simple elixir.............75 c.c. = ℥ ijss.

Mix, and give four cubic centimetres (ʒ j.), in a little sweetened water, every four or six hours, until the more active symptoms are relieved. If the bowels should be irritable or too loose, the cimicifuga or senecio may be substituted in place of the phytolacca in the same proportion to the other ingredients. If the fresh aggravation of symptoms has been sufficiently severe to cause some increase of temperature, with dry skin and white coat upon the tongue, early and more certain relief may be obtained by giving, in addition to the other remedies, five or six decigrams (gr. viij. or x.) of Dover's powder and two decigrams (gr. iij.) of calomel at night, followed by a saline laxative in the morning. For permanent relief or palliation of chronic arthritis it is necessary to maintain, as far as possible, a healthy and natural action of all those organs and functions concerned in the work of eliminating the products of tissue-changes, and other waste and foreign material, from the blood. The best means for doing this are chiefly hygienic rather than medicinal. To lessen the effects of sudden and extreme atmospheric changes, underclothes of flannel or other non-conductor of heat and electricity should be habitually worn next to the skin; damp and cold rooms should be avoided; both physical and mental exercise should be as uniform as possible, extremes in either direction being avoided; the diet should be plain, nutritious, and sufficient in quantity and variety to furnish all the elements for healthy nutrition; and the drinks should be such as do not retard molecular changes in the blood and tissues, nor lessen important excretory functions. Good water, milk in any form, and tea and coffee of moderate strength, may be used *ad libitum;* but all forms of alcoholic drinks, whether fermented or distilled, lessen molecular changes and the elimination of excretory material, and favor the accumulation of such material in the blood and tissues, and therefore should be entirely avoided. In addition to all these ordinary hygienic measures, the use of a warm alkaline bath, followed by light, rapid friction with dry flannel, once or twice a week, has been found of much service in cases characterized by habitually dry skin and high-colored urine. The best time for the bath is just before retiring to bed in the evening. In cases where the circumstances of the patient will permit, a permanent change of residence from a cold, damp, and variable climate to one that is mild and dry, will be the surest mode of obtaining permanent relief. The use of mineral waters containing an excess of alkaline carbonates, both for drinking and bathing, also proves beneficial in many cases.

Strict attention should be given, in all cases, to the keeping of the digestive organs and the secretory functions generally in as healthy a condition as possible. Thus far I have said nothing regarding local applications to the affected joints. In comparatively recent cases, and in temporary exacerbations of old cases, painting the affected parts with tincture of iodine until the skin becomes tender will do some good; or a cautious application of oleate of mercury and morphine may be made morning and evening, for two or three days, and be followed by a liniment containing camphorated soap liniment, 260 grams (℥ viij.,) and menthol, 6 grams (ʒ jss.); this may be applied two or three times a day.

A great variety of local applications, including gentle and continuous currents of electricity, have been devised and recommended by different writers and teachers; but experience has demonstrated their effects to be either useless, or only temporarily beneficial. Chronic rheumatic arthritis is liable to be complicated with gonorrhœal, syphilitic, and gouty constitutional conditions of the patient. Of course, in such cases the treatment must be varied to meet the indications afforded by these complications.

N. S. Davis.

RHEUMATISM, GONORRHŒAL. This is an arthritis, rheumatoid in character, involving a single joint, or at most only a few joints, and in those first attacked generally persisting in a chronic manner for a number of days or weeks; rarely or never suppurating; with never serious, and sometimes no, constitutional disturbance; usually on subsidence leaving some thickening and stiffness of the joints, which may endure for months or permanently; depending on some irritation of the mucous membranes of the genital or the genito-urinary canal, usually gonorrhœal in character. It has no relation with ordinary rheumatism, and the name gonorrhœal rheumatism is misleading. A better name is *urethral arthritis.* Writers on the subject show, by lack of uniformity in descriptions of the disease, as it occurs typically, that they are not entirely agreed as to where to draw the line between this and other rheumatoid affections.

ETIOLOGY.—The disease attacks individuals of any age from puberty up to fifty years. The greater number of patients are men—less than seven per cent. being women. Neither seasons nor temperature particularly influence its occurrence or course; nor does atmospheric humidity or the state of the barometer. Rheumatic subjects are not more prone than others to acquire it; the claim has been made, probably on insufficient grounds, that they are less so, and that a rheumatic diathesis is protective against this affection. A lowered condition of the system, bad surroundings, cold-catching, and exposure, seem to have no direct influence in producing it. Almost without exception it follows urethral or vaginal irritation or inflammation of some description. Nearly always the irritation is gonorrhœal; probably the exceptions do not aggregate one per cent. of the cases, and many of the cases recorded as exceptions are open to challenge. Arthritis occurs occasionally in cases of simple inflammation of the urethra due to passing the sound or catheter, or to the treatment of a stricture, but in such cases it will usually be found that gonorrhœa had previously existed, if not arthritis also. It is one of the rarest clinical observations to see an arthritis resembling this disease follow a non-specific urethritis or vaginitis in a person who never had gonorrhœa. One attack of gonorrhœal rheumatism rather predisposes to another, and in the same joints. A patient may have several successive attacks, each following promptly upon a fresh gonorrhœa, and each involving the same articulations. It has been claimed that irritation of the posterior portion of the urethra must be more prone to produce arthritis, since the affection is never observed in the early days of a gonorrhœa, or when only the anterior portion of the urethra is involved, and since it is less likely to follow a first attack of gonorrhœa than a subsequent one, when the posterior part may be expected to be most affected. Apparent recovery often fails to remove all the products of the inflammation of the joints; some thickening of the tissues about the articulation is usually left, which may itself be the element that invites a fresh attack.

Arthritis follows only a small proportion of cases of gonorrhœa, probably not over two per centum.

Besides the poison and the irritating effects of the urethritis, a positive personal predisposition seems to be required for the occurrence of the rheumatoid affection. The joint inflammation rarely follows promptly the outbreak of urethritis; usually a few days, sometimes several weeks, intervene between them. Statistics that seem reliable appear to show that about sixty per cent. of the cases occur in the third and fourth weeks of the gonorrhœa. The arthritis may come on just as the gonorrhœa is fading away, but usually some change is noticeable in the symptoms of the latter, some aggravation often, before the former occurs. Mild cases of

gonorrhœa are nearly or quite as likely to lead to urethral arthritis as are severe ones.

Several theories of the etiology of this disease have been brought forward, but no one of them is proven. One is that a poison which is characteristic of gonorrhœa —possibly a micro-organism, the gonococcus, or some other—is actually absorbed or taken up from the mucous membrane, and, infecting the system, falls with most force on the parts of greatest susceptibility, which are the joints. It is even claimed that gonococci have been found in the products of the inflammation about the joints and in the blood. But this theory leaves unexplained the few well-authenticated cases of arthritis following non-specific urethritis; it is irrational to suppose in them the existence of such a poison as the theory requires. Another view is that the arthritis is a reflex phenomenon. Another holds that the inflammation extends from the mucous membrane to the sacral plexus of nerves and the spinal cord, and causes disturbance of trophic nerves, which in turn causes the arthritis, as this is produced in diseases of the spinal cord. This theory is as plausible as any. It makes the virus of gonorrhœa of no effect, except to cause an irritation—other irritants might do as well or as badly, and cause as many cases if they were as common. But the fact of the relative insusceptibility of women to the disease is left unexplained by all the theories.

Symptoms.—Gonorrhœal rheumatism usually begins a few days after the outbreak of the gonorrhœa that causes it, with mild febrile symptoms, and slight swelling with some pain and tenderness over one or more joints. Frequently at the beginning a number of joints are affected, the symptoms soon disappearing from all but one or two, where they remain often for weeks. The joints of the lower extremities are most frequently involved, and of these the ankle is much the oftenest affected. Next in frequency of attack is the knee, but the hips, shoulders, elbows, and wrists may be involved, as well as the joints of the hands and feet, the articulations of the jaws, the spine, and the pelvis. A majority of writers state that the knee is most often the seat of the disease, and, of the larger joints, the ankle the least often. Such statements must be based on personal observation in particular fields of practice. In the observations of the writer, in both hospital and private practice in Chicago, the ankle cases outnumber all others. One, or at most two, joints are usually all that become, or that continue, affected, and the arthritis continues in these—which are frequently the joints first attacked—till the end of the sickness, which is from two to twelve or more weeks in duration. In probably a fifth of all the cases the lesion is confined to a single joint.

The swelling, at first slight, increases gradually until it attains sometimes formidable proportions, and may thus remain for many days in spite of any and all treatment. The heat in the part is not great, nor is the tenderness usually, and the swelling, if it is discolored at all, has a dull redness quite in contrast with the appearance of an actively inflamed joint. The swelling and inflammation are evidently mostly of the tissues about the joint proper, since pressure of the articular surfaces against each other rarely causes pain. Any considerable motion of the limb or manipulation of the joint, however, causes pain, usually of a mild character, but sometimes severe and lasting long after its occasion has ceased.

As it occurs in the majority of cases, the general aspect and character of the arthritis stamp it as a process of a subacute and sluggish character. The signs and symptoms of intense and sthenic inflammation are wanting.

Usually there is but slight effusion into the joint. Hydrarthrosis occurs in a small minority of the cases, mostly of the knee, in some of which effusion is extreme, but in most it is slight. When dropsy of the joint does occur the inflammation of the tissues about the joint is relatively less severe, and the slight degree of the synovial inflammation is evidenced by the fact that aspiration of the fluid is often not followed by its reappearance.

There is, with the rarest exceptions, no destruction of the tissues of the joints, hence suppuration and ulceration of the synovial surfaces and structures are among the most infrequent occurrences.

As the affected joint slowly improves, the swelling abates, but it rarely disappears rapidly, and generally some stiffness of the articulation persists for a long time, or permanently. At times the effusion within and about the joint attains such a degree of consolidation that the joint is immobilized by a false anchylosis. A few cases are recorded where several, and one where nearly all, the joints of the body became fixed and motionless from successive attacks of this disease. In the cases of anchylosis moderate swelling remains about the joint, but the latter may become quite insensitive, and locomotion and bodily movements may be attended with the sole inconvenience resulting from the slight or complete abolition of motion in the articulations affected.

The constitutional symptoms of the disease, uncomplicated, are very rarely severe, and, after the first few days, may be absent. They embrace merely the evidences of a mild inflammatory fever, with its usual disturbances of the functions of the system, with anorexia, general pains, and restlessness. The temperature and pulse-rate are rarely high, and at the end of from three to seven days the system has usually resumed its normal conditions, except as to the local lesion. The general symptoms of ordinary acute rheumatism, such as continued fever, free perspiration, and excessive deposit of urates in the urine, are absent in this affection. Occasionally the arthritis is attended with more or less neuralgia, which may become extreme. The pain is sometimes most severe in cases attended with slight inflammation and swelling.

The occurrence of the arthritis does not influence the gonorrhœa, except during the first few days of fever. This condition may retard its recovery slightly; but as soon as the system resumes its normal condition, the gonorrhœa may improve, and pass on to recovery long before the joint affection. Indeed, in some cases the arthritis appears to exercise a decidedly beneficial influence on the gonorrhœa.

Complications and Peculiarities. — Urethral arthritis may be complicated by inflammation of the bursæ, the muscles, and the periosteum in the neighborhood of the swollen joints, by endocarditis, pericarditis, meningitis, myelitis, by adenitis, or by pyæmia. Ophthalmia occurs as a complication of the gonorrhœa by transmission of the poison to the conjunctivæ, rather than as a complication of the gonorrhœal rheumatism. The complications referred to are rare; the cardiac lesions being the most common. Probably more than four-fifths of all the cases of gonorrhœal rheumatism run the typical course already referred to without complications of any sort. Certain it is that heart lesions are not, in this disease, sufficiently frequent even to suggest any such predisposition in this direction as exists in ordinary acute rheumatism. As to the other lesions, whether they are complications of the gonorrhœa or of the rheumatism, is often uncertain. This is particularly the case with pyæmia, which may more rationally be supposed to arise from an inflamed urethra discharging quantities of pus, and perhaps being prodded by injection-tubes, if not worse instruments, and harassed with irritating medicines, than from arthritis, unless the joint be open to the air and suppurating.

Morbid Anatomy.—The usual lesion is a deposit of plastic material in the tissues about and of the joint. The failure of absorption of this is the common cause of the false anchylosis. Sometimes the effusion is into the joint-cavity. In these cases the synovial membrane is chiefly involved; in them the effusion may contain flakes of fibrine and leucocytes. Large effusions into the joints are very rare. Suppuration is extremely unusual, as is also erosion of the bony tissues. In exceptional cases the inflammation travels up the synovial sheaths.

Diagnosis.—This affection is liable to be confounded with a number of other diseases; among them acute rheumatism, chronic articular rheumatism, and the arthritis of pyæmia. From acute rheumatism it may be distinguished by the greater tendency in the latter to migra-

tion of the inflammation from joint to joint, by the greater intensity of the constitutional symptoms, and by the greater severity of the local pain and tenderness, as well as by the greater tendency to heart-lesion.

Chronic rheumatism may be confined to a single joint, or a few joints; but it very rarely causes such considerable swelling as is general in gonorrhœal rheumatism; and it nearly always fluctuates with changes in the barometric pressure, being worse on the approach of a storm—times of low barometer,—a behavior most unusual to urethral arthritis. The arthritis of pyæmia is most likely to be mistaken for this disease when the source of the infection is in the neighborhood of the urethra, when non-specific suppuration in the urethra, the prostate gland, the body of the penis, or some of the veins of these organs, has caused the pyæmia. But usually some of the characteristic general symptoms of pyæmia, and which are almost unknown in gonorrhœal rheumatism, make the diagnosis clear.

It must be borne in mind that true acute articular rheumatism may occur in the course of urethral arthritis.

Gonorrhœal rheumatism should be suspected, regardless of sex or condition, whenever, in a person of an age at which gonorrhœa is liable to be contracted, one or two joints become inflamed or swollen, without much serous effusion, showing little tendency to recovery, and pursuing the sluggish and peculiar course already described. It is not necessary to suppose every such person to have gonorrhœa; urethral or vaginal irritations not gonorrhœal, even other irritations, *may* cause the disease. But true gonorrhœa is found sometimes in unexpected quarters. It has more than once occurred to the writer, in hospital practice, to discover the true cause of what had been supposed to be an obstinate subacute rheumatism in the ankle of a young woman of supposed purity, in her confession of an irregular life and of having an irritating leucorrhœa and frequent, painful micturition. In all cases of arthritis that are not clearly of the character of ordinary rheumatism, inquiry should be made as to the condition of the urethra, both past and present, to ascertain whether there are any pus-discharging surfaces.

Prognosis.—The prognosis of an initial attack is favorable. Complete ultimate, albeit slow, recovery usually takes place, with some stiffness, however, remaining long after other evidences of the disease are gone. But each successive attack is more severe than the preceding, is more chronic, and more rebellious to treatment; and the danger of false anchylosis increases with the repetitions of the attacks. Persons are increasingly obnoxious to attacks of this disease with successive gonorrhœas, and after a gonorrhœa—especially if it has been followed by the arthritis—this affection is very liable to occur from any slight and non-specific urethral irritation, like that resulting from the touch of a catheter or sound, or even from urethral catarrh due to cold or any excess.

After a joint has remained swollen and stiff for six months, the prospect of its recovery is small, and any amelioration of its condition will generally be vexatiously slow.

The various complications make the prognosis more grave, in degree varying according to their character and severity.

Treatment.—The first step in the treatment is to cure the gonorrhœa. Often at the outbreak of the arthritis the gonorrhœa is insignificant; sometimes when severe at the moment of the appearance of the joint-trouble, it rapidly subsides if the constitutional symptoms are not marked. When it does not subside promptly, it should be treated as the first measure toward the betterment of the arthritis. There can be small expectation of any substantial improvement in the latter while the urethra is still inflamed. Not only should the gonorrhœa be cured as rapidly as possible, but all possible sources of irritation of the urethra should be removed; the urine should be rendered unirritating and be kept so; the diet must be unstimulating, large draughts of bland liquids must be drunk, and the bowels are to be kept open with cooling laxatives. Therapeutic measures are wanting to relieve directly many of the most obstinate cases of the arthritis; this will often, in spite of everything, drag along for months, but the substantial benefit that comes from removing all other irritations, and especially that of the genito-urinary system, is always within reach.

The acute symptoms of inflammation and fever may profitably be combated by the usual measures of anodynes for pain and discomfort—laxatives, low diet, quinine, hot fomentations, and, in cases of high temperature, antipyretics. This treatment is demanded alike for the comfort of the patient and for the possible abbreviation of this stage of the disease, although as to its great value in the last-named direction there is some doubt.

The post-acute stage, that in which the disease is confined to one or a few joints, may be treated with some advantage by the internal administration of alteratives—the iodide of potassium, biniodide or bichloride of mercury in moderate doses, and locally with rest, counter-irritants of croton-oil, tincture of iodine, frictions, and pressure, according to the needs of the case. Neither the salicylates nor any other of the so-called specific treatments for acute rheumatism have any special influence in this disease.

The course of many cases is extremely chronic, and often the practitioner is in doubt whether the most active treatment particularly hastens the recovery from the joint-affection. After the acute stage is fully passed the joint-thickening may be somewhat reduced by the systematic employment of massage. False anchylosis of long standing is remediless, except, perhaps, by breaking down by force the adhesions, and making and maintaining motion of the joint, a manœuvre that has been recommended.

Norman Bridge.

RHIGOLENE. Of the products of the fractional distillation of petroleum the lightest is obtainable as a fluid by condensation, and consists mainly of the paraffin *butane*, a body gaseous under ordinary conditions. This condensed distillate is termed *cymogene*. The distillate of next higher boiling-point boils at about 18° C. (64.4° F.). Such distillate consists largely of the fluid paraffin *pentane* ("amylic hydride"), C_5H_{12}, and is the substance commonly known as *rhigolene*. Rhigolene is a colorless, mobile fluid of slight and not unpleasant odor and taste; very light, very inflammable, and, as its boiling-point predicates, very volatile. It mixes in all proportions with common (ethylic) ether. Rhigolene was proposed by B. W. Richardson as a substitute for ether for the production of local anæsthesia by freezing, after his method. Because of the low boiling-point of rhigolene—lower than that of ether—the cold produced by the evaporation of a spray of rhigolene is very intense and very rapidly attained. Dr. Richardson has himself observed an area of skin become hard, white, and insensible at the expiration of *two seconds* after beginning the driving upon it of a rhigolene-spray. But such very rapid freezing Dr. Richardson finds undesirable, because the intense cooling of the superficial frozen area prevents the abstraction of heat from below, and so unduly limits the depth to which the anæsthesia can be carried. Hence Dr. Richardson prefers and proposes a mixture of rhigolene and anhydrous ether in equal parts. Rhigolene dissolves camphor, spermaceti, and iodine, and has been used by Richardson, again, as a solvent of those bodies for use for local applications. A rhigolene-solution of camphor and spermaceti together Richardson finds an excellent conjoint cooling anodyne and healing application to burns. The vapor of rhigolene, inhaled after the manner of vapor of chloroform, is readily taken, and produces general anæsthesia with great rapidity. But in this application rhigolene has shown itself dangerous, and has never come into practical use.

Edward Curtis.

RHINOSCLEROMA. Under this head Hebra described, in 1870, a disease seated in the nose, nasal passages, and pharynx, characterized by nodular swellings and infiltration of the affected parts, and a stony induration. As its name implies, the nose is the part most affected, and

the disease afterward involves the surrounding skin, the lips, and the mucous membrane of the mouth, the pharynx, and the larynx. It appears in the shape of smooth or nodular masses which are sometimes isolated, but generally merged into one another, so that the whole forms a connected mass. These nodules are very firm, slightly elastic, and sharply circumscribed from the surrounding healthy skin. The skin covering the growth is of a bright or dark red color, shiny, and contains many small blood-vessels, which form a visible net-work. It is perfectly smooth, and the hair- and gland-follicles are absent. The growth appears very similar to a keloid or hypertrophic scar, the skin having the same smooth, shiny character which is the result of the absence of hair-follicles and glands. As a rule, the growth first appears as a thickening and induration of the septum cutaneum, or of one of the alæ, without any inflammatory phenomena. After the disease has lasted many months the nose appears broader and flatter than normal, and the nostrils are rigid and dilated. On feeling the growth the peculiar hardness characteristic of it can be appreciated. The nose feels as

FIG. 3327.—Rhinoscleroma; case of Tanturi. (Copied from Schulthess.)

if it were cast in plaster of Paris, and the dilated nostrils cannot be closed. Hebra compares this induration with that of an initial syphilitic sclerosis, and says that the best idea of it can be obtained by supposing it to be one immense smooth chancre. It is not painful, except on pressure. In the course of time the disease advances in two ways. The most frequent course is along the nasal passages to the pharynx and palate. The nodular masses and induration extend backward, narrowing, and in some cases entirely closing, the nasal passages. The soft palate is attacked, becomes greatly thickened, and is frequently so deformed that it merely resembles a thick cord. Adhesions often form between the palate and the posterior wall of the pharynx, and deformities similar to those produced by extensive syphilitic ulceration and cicatrization may result. From its beginning in the nose the morbid process may extend to the upper lip and the mouth. The lips become nodular and thickened, and the orifice of the mouth may be so narrowed that operative procedures are necessary to enable the patient to take food. The gums and hard palate are more rarely affected. When this takes place the gums are swollen and indurated, the teeth become loosened and drop out, and the alveolar processes atrophy. From the mouth the disease may extend to the palate and pharynx, but in most cases infection follows from the other direction. The changes produced in the larynx are of great importance. The growth may involve the epiglottis and the mucous membrane of the larynx, producing fixation of the epiglottis, with aphonia, suffocation-phenomena, and epileptoid attacks. Catti has described a case in which the larynx was first attacked, and two years after this the characteristic growth in the nose appeared. In a case recently described by Schulthess, the disease appeared to have begun in the lachrymal duct, and made its first appearance as a nodule in the corner of the eye. After several years the nose, pharynx, and larynx became successively involved.

The growth advances very slowly. From its first appearance it often takes four or five years for the nodule to attain a superficial diameter of four or five centimetres ($1\frac{1}{2}$ to 2 inches), and cases are often seen which have lasted twenty years or more. In the case described by Schulthess the disease at the time of publication had lasted twenty-four years. Ten years had elapsed from its first appearance before the tumor-masses in the nose appeared, and the larynx became involved six years after this.

The absence of any tendency to suppuration and retrograde changes is one of the most striking features of the growth. Microscopically, the areas of fatty degeneration and coagulation necrosis, so common to most of the granulation-tumors, are not found. Even when it is cut into, and a piece excised, the wound quickly becomes covered with epidermis, and the part removed is soon replaced. On cutting into the tissue it is surprising with how much ease the knife enters it.

The subjective symptoms depend entirely upon the functional disturbances produced by the growth. The most prominent is the dyspnœa produced by the narrowing of the respiratory passages. The affection seems to exert absolutely no influence on the general constitution, independent of the functional disturbances spoken of. There is never any metastasis nor involvement of the lymphatic glands. The affected parts are never painful, except on pressure. Occasionally there may be a dacrocystitis, from an involvement of the lachrymal duct and a growth in the corner of the eye.

The first histological description of the disease was given by Kaposi, who studied some of the earlier cases published by Hebra. He describes the growth as a small-cell granulation-tumor, and regards it as a species of sarcoma. He denies that there is any transformation of the round cells into connective tissue, although he speaks of the cicatrization produced in the palate and elsewhere. Mikulicz, basing his conclusions upon a careful histological study, regards the entire process as chronic inflammation. According to him, a part of the round cells become changed into spindle-cells and connective tissue, which afterward undergoes cicatricial contraction. The microscopic study of the growth is best made by excising small pieces and hardening them in alcohol. Sections may then be made and stained with various reagents. Like most of the other granulation-tumors, the growth is principally composed of small round cells. Among these, sometimes lying singly, at other times in groups of two or three, are large cells which are more or less characteristic of the growth. In the older portions of the growth the round cells are pretty uniformly distributed throughout the tissue, but they are never so closely packed together as in most of the other granulation-tumors. The large cells have a protoplasmic net-work and contain two or three nuclei. They frequently contain round masses of a hyaline or colloid material, which stains with most of the aniline colors. A similar material is found in irregular masses scattered throughout the tissue between the cells. The cellular infiltration extends up to the epidermis, which is very thin, but which passes uninterruptedly over the growth. In places the epidermis sends down long projections into the tissue beneath. The glands generally atrophy and disappear, though in some cases, after closure of the ducts, small cysts are formed. In the younger portions of the growth the cellular infiltration is not so extensive, and is principally seen around the vessels. Bands of connective tissue with spindle-cells are

seen here and there, but the amount of connective tissue present is not so much as one would expect to find in view of the extraordinary hardness of the growth. In addition to these larger bands small masses of fibres are found here and there between the cells. The firmness of the tumor is principally due to the presence of the hyaline colloid material.

In 1882 Fritsch reported that he had found constantly in the rhinoscleroma short bacilli, which he was able to cultivate in aqueous humor. He made inoculations with the cultures, but did not get any results. From the constant presence of these bacteria he regarded them as causative of the disease. The best description of the bacteria is given by Cornil and Alvares, from whose drawings the accompanying figure is taken. The bacteria are principally found in the large protoplasmic masses which have been spoken of as characteristic of the disease. In addition, they are found in the interstices of the tissue and in the lymphatic vessels with which the tumor is abundantly supplied. They are short rods, and under low powers have more the appearance of micrococci than of bacilli. In the large cells they are in groups of from ten to twenty. In the lymphatics they are generally free. Cornil and Alvares described as characteristic of them small clear masses or capsules which surrounded them. Sometimes there is a constriction in the middle, giving the appearance of two bacilli enclosed in a single capsule. The capsule is best seen after staining with aniline water gentian violet, and then decolorizing with iodine. The bacteria present the most striking similarity to the Friedländer pneumonia-bacilli, and can be distinguished from these neither by their morphological

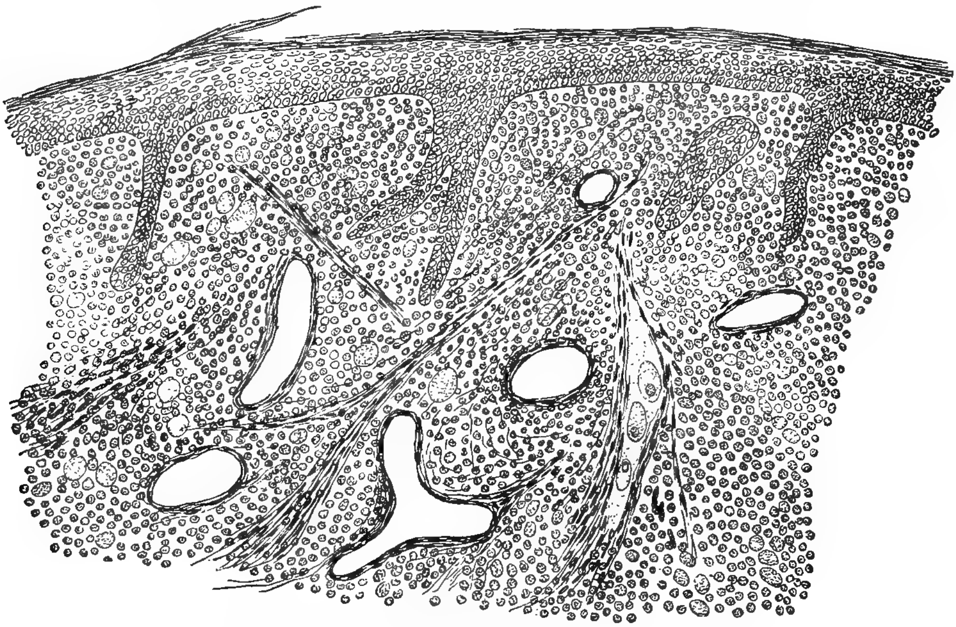

FIG. 3328.—Section through a Nodule of Rhinoscleroma. × 60.

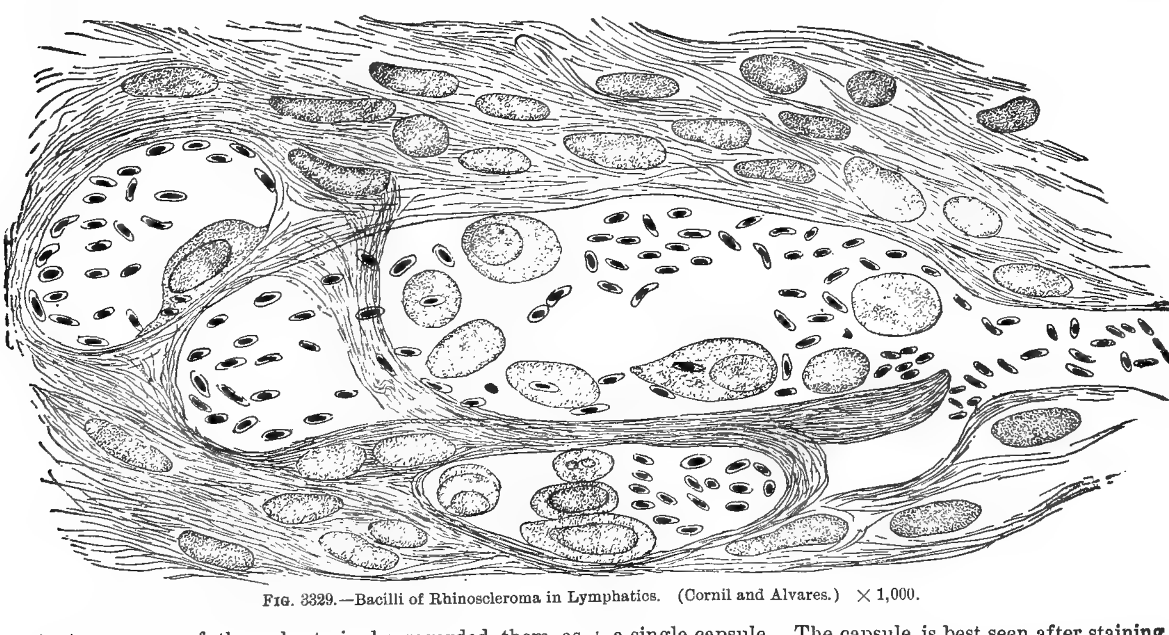

FIG. 3329.—Bacilli of Rhinoscleroma in Lymphatics. (Cornil and Alvares.) × 1,000.

characters nor by culture. They have recently been made the subject of careful study by Paltauf and Eiselberg. They made numerous inoculations in various animals, and succeeded in producing in mice the same changes that are produced by the pneumonia-bacilli. It is difficult to say with certainty whether or not these bacteria are the cause of the growth. They are invariably present, and their situation in the large cells and lymphatics shows that their presence is not an accidental one. Remarkable as is their resemblance to the Friedländer bacilli is, we are by no means justified in regarding them as identical. The very fact of the extreme rarity of the rhinoscleroma and the frequency with which Friedländer bacilli are found speaks against this view. In addition to this, the rhinoscleroma has a well-defined geographical distribution. Most of the cases have been found in Vienna, which may be regarded as the home of the disease. A few cases have been found elsewhere in Austria, a few in Italy, and one (that of Schulthess) in Switzerland. No cases have been met with in the United States, although several have been seen in Central America.

The diagnosis of the disease is comparatively easy. Hebra has given the following as the most marked characteristics: 1, The seat of the disease, which is in the nose or in parts immediately adjacent to it; 2, the peculiar hardness of the part affected; 3, the extremely slow development; 4, the sharp limitation of the growth, and the absence of œdema or of any inflammatory reaction in the surrounding tissues; 5, the absence of retrograde metamorphosis; 6, the inutility of all internal treatment; 7, the benign character of the growth as regards the organism, even when it has lasted years; 8, the absence of pain except on pressure. The only affections with which there is any probability of confounding it are syphilis and epithelioma. From the former it may be distinguished by its circumscribed growth, absence of ulceration, and the inutility of specific treatment; from the latter by absence of ulceration, its painless character, history of slow growth, and absence of infiltration of the surrounding tissue.

The treatment is confined to excision of parts of the growth, when it endangers life by closure of the nares, etc. No medication has been found to be of any avail, and by reason of the extent of the growth complete excision has not been found to be practicable. Frequent operations are necessary, as the portions removed are quickly reproduced.

W. T. Councilman.

RHINOSCOPY. Inspection of the nasal cavities and retro-pharynx is accomplished by two methods of examination. These are anterior rhinoscopy and posterior rhinoscopy.

Preliminary to the investigation of the nasal canals, it is well to observe the exterior of the nose. From the appearance of this, some suggestion may be obtained as to the existence of abnormalities within. Thus, deflection of the nasal septum is often attended with irregularity of external contour; the presence of an intra-nasal growth is attended with bulging of the alæ or distortion of the nasal bones, causing in extreme cases the appearance known as "frog face;" occlusion of the nasal passages and mouth-breathing are associated with the peculiar upturning and enlargement of the end of the nose, or, on the other hand, with the pinched, atrophied, and collapsed condition of the alæ commonly observed in such patients; chronic catarrh is attended with congestion and thickening of the alæ; and, finally, there may be actual depression of the bridge of the nose from surgical injury or from tertiary syphilis.

Although by no means infallible, the above are often useful guides toward a diagnosis. Again, the ease with which the exit of air is effected through one nostril, the question as to whether or not the patient can breathe for any length of time with the mouth closed, the existence of fetor in the expired breath, the quality of the voice, and the condition of the olfactory sense, are points of importance in the examination which are capable in many cases of conveying information, and which should not be neglected.

Inspection of a wide nostril may sometimes be partially accomplished by placing the patient opposite a strong light and then forcing upward the tip of the nose. This, however, is unsatisfactory. For the accomplishment of a thorough examination it is necessary to use, first, a good light; and, secondly, something in the way of a speculum by which the nostril can be dilated and the light thrown into the dark and remote passages which are to be examined.

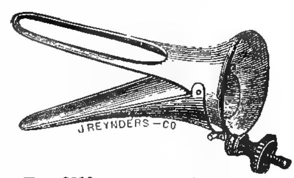

FIG. 3330.—Duplay's Speculum; modified.

Both anterior and posterior rhinoscopy may be efficiently performed by means of sunlight, and in some cases this is to be preferred. In most instances, however, the simplest and most convenient method will be by artificial light, and with the appliances used in the performance of laryngoscopy (see vol. iv., p. 385).

For the performance of anterior rhinoscopy many ingenious specula have been devised. Among the different kinds commonly sold by the instrument-makers, those pictured in the accompanying cuts (Figs. 3330 to 3332) will be found useful and convenient.

A very valuable form of nasal speculum is that of Sigmund, a tubular instrument made of hard rubber and shaped like an ear-speculum. It is particularly useful in the application of the galvano-cautery to the nasal cavities. An excellent substitute for a nasal speculum may be improvised from a common hair-pin by bending both ends of the pin in opposite directions, and thus forming a double curve, one end of which is held in the operator's hand and the other pressed outward against the ala of the nose.

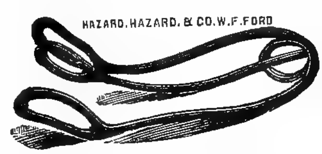

FIG. 3331.—Goodwillie's Speculum.

Among other good varieties may be mentioned Fraenkel's, Bosworth's, Creswell Baber's, and John N. Mackenzie's.

For the performance of anterior rhinoscopy the patient should be seated as for a laryngoscopic examination, and the arrangement of the light, the head, mirror, etc., should be the same as for the latter (see vol. iv., p. 386). The blades of the speculum should then be introduced into the vestibule of the nose and separated. The vestibule itself is lined with integument and furnished with an abundant growth of short, stiff hairs, which, for facilitating the examination, it is sometimes desirable to cut off. This, however, is seldom necessary. At the posterior superior limit of the vestibule is the opening of the anterior nares. Here the integument changes its character and becomes mucous membrane. Professor Wilhelm Meyer, of Copenhagen, has observed that in cases of chronic catarrhal disease the characteristics of the external integument are preserved to an unusual distance posteriorly.

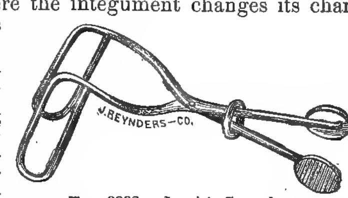

FIG. 3332.—Jarvis's Speculum.

Upon inspecting the nasal fossa, which is brought into view by the nasal speculum, the patient's head being bent somewhat forward, the first objects seen will be the anterior aspect of the inferior turbinated body and the lower part of the cartilaginous portion of the nasal septum. Beyond these may be seen the inferior meatus, the floor of the nose, and the lower border of the inferior turbinated body. Tilting the head a little backward, the remainder of the inferior and part of the middle turbinated bodies come into view. And, bending the head backward still farther, the uppermost part of the middle turbinated body and the roof of the nasal fossa can be seen.

The superior turbinated body may sometimes be demonstrated anteriorly, although this is unusual. Under inspection in the above positions, with the head turned a little to one side, the corresponding parts of the septum can be demonstrated.

The color of the nasal mucous membrane varies in different situations. The anterior and inferior border of the inferior turbinated body, and the floor of the fossa, are usually bright red, while the septum and the inferior border of the middle turbinated body are of a paler hue.

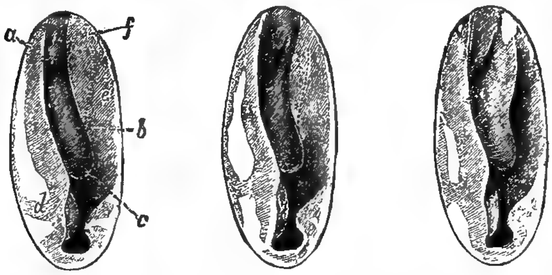

FIG. 3333.—*a*, Outer lip of anterior border of middle turbinated body; *b*, angle of middle turbinated body; *c*, lower border of middle turbinated body; *d*, inferior turbinated body; *e*, tubercle of septum; *f*, outer wall of nasal cavity. In diagrams A and B, the margins of the middle turbinated body, hidden by the tubercle of the septum, are indicated by dotted lines. (Cresswell Baber.)

The description of the contour of the parts seen by anterior rhinoscopy, and their recognition by one not accustomed to such examinations, are matters of considerable difficulty. They have been made much more clear and easy by the excellent work of Mr. Cresswell Baber, of Brighton, England, who, through a series of diagrams and illustrations, has sought to depict the real conditions normally present, and to assist the learner in understanding the variations in form which may occur in pathological states. The accompanying diagrams, while intended to illustrate the different appearances of the tubercle of the septum, convey an excellent idea of the neighboring parts.

As will be seen from these cuts, the extent of view obtained of the middle turbinated body will depend largely

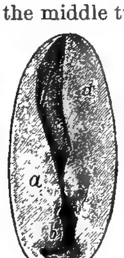

FIG. 3334.

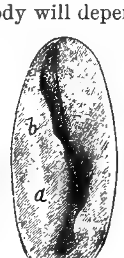

FIG. 3335.

FIGS. 3334 and 3335 represent respectively the right anterior rhinoscopic view of a man, aged twenty-four, before and after erection of the anterior end of the inferior turbinated body. (About twenty minutes elapsed between the times of drawing the two sketches.)

In Fig. 3334, *a* is the collapsed anterior end of the inferior turbinated body; *b* is the inner surface of ditto, which leaves a space between it and the septum, through which the palatal movement can be plainly seen. Above, the middle turbinated body *c* is visible, its neck being hidden by the tubercle *d*.

In Fig. 3335, *a* is the erected inferior turbinated body, terminating above in the swollen "neck" *b*, which almost entirely conceals the middle turbinated body. The upper parts of the drawing are slightly diagrammatic. (Cresswell Baber.)

upon the prominence of the tubercle of the septum. Undue prominence of this part may be reduced by the application of cocaine. When the erectile tissue of the anterior angle of the inferior turbinated body (*a*, Fig. 3335) is tumefied, this body appears as a rounded, shining eminence, having a smooth surface, which is in contact with or close to the nasal septum. Above, it is prolonged into a broad neck (Fig. 3335, *b*), the inner or free margin of which, if its erection be extreme, is in contact with the septum, and completely conceals the middle turbinated body.

When the soft parts lining the anterior aspect of the inferior turbinated body and the lower part of the septum are tumefied, or hypertrophied, the entrance of light to the nasal fossa will be greatly facilitated, as has been suggested before, by the use of cocaine. This drug, applied in a solution of from two to four per cent., will cause more or less complete retraction of the projecting tissues, and thus render possible a far more thorough and satisfactory inspection.

In the examination of the anterior nares, a short, delicate probe will give much assistance, as by its use the appearances conveyed to the eyes can be verified or disproved, the consistence of various parts fairly estimated, and, with the aid of a pledget of absorbent cotton, secretions which obscure the view may be removed. In all cases in which secretion exists, it must be recognized, and, if too great in amount to be dealt with in the way just alluded to, it should be removed by means of atomized spray or the ordinary nasal douche. Of the three methods the spray is likely to do the least injury, and is in a large proportion of cases the best.

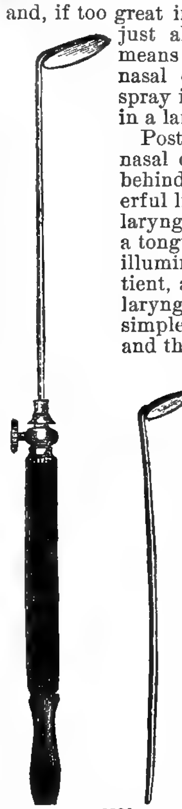

FIG. 3336.

Posterior rhinoscopy, or inspection of the nasal cavities and the upper pharynx from behind, is accomplished by means of a powerful light, a mirror similar to that used in laryngoscopy, only smaller in diameter, and a tongue-depressor. The conditions, as to the illumination and as to the position of the patient, are the same as for the performance of laryngoscopy (see vol. iv., page 386). The simplest and best form of rhinoscopic mirror, and the one in by far the most general use, is illustrated in Fig. 3336. As the reflecting surface is at best very small, and as in the use of the mirror much depends upon the perfection of its form in regard to certain details of shape and construction, it is important that the following points should be observed in selecting one: The reflecting surface should be perfect, the mirror itself as thin as can be made, and not more than one-sixteenth of an inch in thickness, while the metallic edge in which it is encased should encroach upon its reflecting surface as little as possible. Again, the shaft should be attached directly to the margin of the mirror, and not form an angle after leaving it; and finally, the shaft should be slightly flexible, so that, should occasion require, the angle at which it is set into the mirror may be altered.

Tongue-depressors are offered by the instrument-makers in great variety. These should be silver- or nickel-plated, and as free as possible from projections and irregularities of surface, so that absolute cleanliness may be easily secured. One of the most useful varieties ever devised is that invented many years ago by Türck. (For the use of the tongue-depressor and the examination of the lower pharynx, see vol. iv., page 387.)

For the performance of posterior rhinoscopy the patient should be placed in the laryngoscopic position, and a strong light should be thrown into the pharynx, the tongue being depressed. The rhinoscopic mirror, warmed to the temperature of 100° Fahrenheit, should be passed backward to the soft palate, behind which it should then be gently placed, care being taken not to provoke irritation by touching any of the adjacent parts. The positions necessary to a successful examination are well illustrated in Fig. 3337. The position of the velum palati should be such that the space between it and the posterior wall of the pharynx should be as wide as possible. In other words, the velum being perfectly re-

laxed, should hang well downward and forward. This may be accomplished by directing the patient to endeavor to breathe through the nose, the mouth being open, or by his pronouncing a purely nasal sound. The mirror having been introduced, the hand of the operator should be carried outward, so that the entrance of light to the pharynx may be unobstructed. By reason of the size and configuration of the upper pharynx, it is

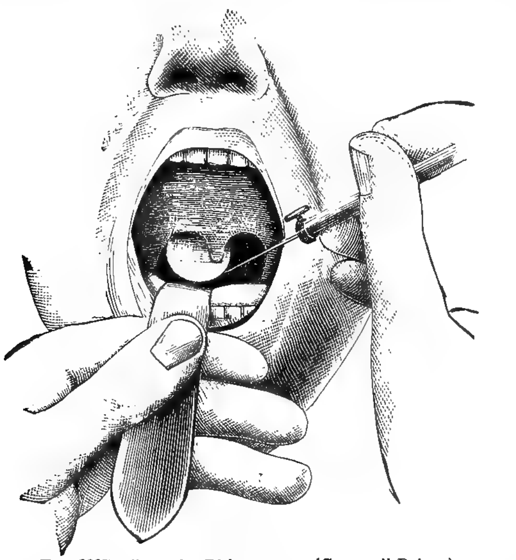

FIG. 3337.—Posterior Rhinoscopy. (Cresswell Baber.)

necessary to change the position of the mirror in order to demonstrate the whole cavity. The recognition of the different parts is somewhat difficult and confusing to the beginner, who will find it of great assistance to observe the following suggestions: In the first place, the normal anatomy of the region should be thoroughly understood. This may be easily acquired by studying the illustrations of the naso-pharynx in any standard work upon anatomy (see Fig. 3338). Upon introducing the rhinoscopic mirror, let the first endeavor be to demonstrate the vomer, which is not only the easiest object to bring within the field of the mirror and to recognize when seen, but, being in the median line, may serve as a point of departure for the rest of the examination; for,

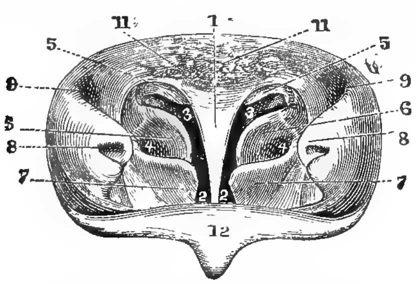

FIG. 3338.—The Rhinoscopic Image. 1, Vomer; 2, nasal passages: 3, superior meatus; 4, middle meatus; 5, superior turbinated bone; 6, middle turbinated bone; 7, inferior turbinated bone; 8, pharyngeal orifice of Eustachian tube; 9, upper portion of fossa of Rosenmüller; 11, glandular tissue at the vault of the pharynx; 12, posterior surface of the palate and uvula. (Cohen.)

starting with this and carrying the light upward, the roof of the nasal fossæ and the vault of the pharynx, with Luschka's tonsil, will come into view; while forward will be seen the posterior extremities of the three turbinated bodies, and outward the lateral wall of the pharynx, the orifice of the Eustachian tube, and the parts adjacent to it on the corresponding side.

In the examination of the upper pharynx certain difficulties may arise. Thus, the pharyngeal space may be unusually narrow, and the neighboring walls so thickened, congested, and coated with mucus, that it is impossible to gain a view of the regions above. Cleansing the mucous membrane and the application of a solution of cocaine, under such circumstances, will sometimes render a fair demonstration possible. The fact remains, however, that in certain infrequent instances the pharyngeal space is so reduced in size that an examination with the mirror is impossible, even in skilful hands. Yet such cases, it must be admitted, are sure to be less and less frequently met with as the experience and dexterity of the examiner become greater. Where examination with the mirror is impracticable, the method of palpation may be employed. Great caution and gentleness should be observed in its application.

An elongated and thickened uvula may offer a serious obstacle. Amputation of the redundant portion will render the examination easier.

Irritability of the pharynx may be overcome by the application of a solution of cocaine—two to four per cent.—or by the rapid drinking of ice-water, or the sucking of cracked ice.

Finally, it may sometimes be necessary to draw the velum palati forward by means of some form of instrument or device suitable for the purpose. Of the instruments which have been proposed, the most useful is a simple probe, covered with the material used in the English flexible, woven catheters. This seems less irritating than the unprotected metal.

Surgeon-General Wales, of the United States Navy, has devised the plan of passing a piece of tape backward through each nostril to the pharynx, and thence under the velum and forward, until the end is brought out of the mouth; the two ends of each tape are then tied together with sufficient tension to draw the velum well upward and forward. For operations in the upper pharynx this method, or some modification thereof, is very useful. *D. Bryson Delavan.*

RHUBARB (*Rheum*, U. S. Ph.; *Rhei Radix*, Br. Ph.; *Radix Rhei*, Ph. G.; *Rhubarbe de Chine, Rhubarbe de Muscovie, Rhubarbe de Perse*, Codex Med., etc.).

"The root of *Rheum officinale* Baillon, and of other undetermined species of *Rheum*, Order *Polygonaceæ*," U. S. Ph. "The root, more or less deprived of its bark, sliced, and dried, of *Rheum palmatum* Linn.; *Rheum officinale* Baillon, and probably other species. Collected and prepared in China and Thibet," Br. Ph.; of *R. officinale*, etc., Ph. G.; of *R. palmatum* Maxm.; *R. tanguticum* Linn.; *R. officinale* H. R. N., etc., Codex Med.

The sources of Asiatic Rhubarb, for they are undoubtedly several, are not known with anything like exactness, although upward of half a dozen have been designated by travellers and botanists. Most of these, upon examination of the structure of their roots grown in Europe, can be proved *not* to be the same as the commercial Rhubarb, but one or two may still be the same. The general features of the genus are familiar in the cultivated "Pie-plants," *R. Rhaponticum*, etc. They are large perennial herbs with very thick, fleshy roots, and immense leaves. The flowering stems, from four to ten feet high, are thick, hollow, more or less leafy and branching. Flowers small, numerous, green or whitish, sometimes pink or red. They have a six-parted perianth, nine stamens, and a three-cornered, one-ovuled superior ovary, with three recurved styles. The ovary is surrounded at its base by scales or glands. It develops into a three-angled, one-seeded achene. There are twenty or more species, all from Central and Southern Asia.

R. officinale Baillon. This fine, large species is one of the latest discovered, being made known through French missionaries in Thibet, in 1867. Specimens were sent about that time to Paris, where they have grown well, and from whence plants have been obtained for other gardens. It is quite hardy, grows freely, and produces a root that microscopically agrees with Asiatic Rhubarb. It is a large, handsome species, developing a thick, aerial, branching stem, several inches in diameter and a foot or

more long, tapering to a blunt apex, and covered with brown leaf-bases. It is internally fleshy and yellow, or orange. Roots also very large and thick. The lower leaves are very large, on long, cylindrical petioles, and form a pyramidal mass of foliage six or eight feet in diameter; their blades are roundish, heart-shaped, palmately veined, deeply lobed and serrate; the veins and petioles are very thick; under-surface pubescent. Flowering stems from five to eight feet high, much branched, terminating in numerous graceful, spike-like clusters of flowers.

R. palmatum Linn. has long been considered one of the sources of Rhubarb. It is also a very large herb. It has deeply lobed leaves on semi-cylindrical stems, and a rather close paniculate and compound inflorescence. It is a tenderer and more delicate plant than the preceding, and its root, at least as cultivated in Europe, does not correspond in structure with Asiatic Rhubarb (Flückiger). It is a native of Chinese Tartary. *Var. tanguticum*, according to M. Przewalski, is cultivated and collected in the place of that name in the Province of Kansu, of Northern China.

Fig. 3339.—Rheum Officinale. (Baillon.)

Besides the above, the following certainly do not produce genuine Rhubarb, although they have been considered to do so at one time or another. They are sources, however, of European Rhubarb, and are besides extensively cultivated in Europe and here for their pleasantly sour petioles, which by high cultivation and blanching grow very large and long.

R. Rhaponticum (Pie-plant) has semi-cylindrical petioles, and entire, wavy, heart-shaped leaves; *R. undulatum* has the upper side of the petiole concave, and sharply pointed leaves; *R. compactum* Linn. has serrated leaves; *R. australe* has round, broadly heart-shaped, rough leaves, etc.

All the above are from Central Asia, but they have been cultivated for a considerable time in Europe, either as "pie-plants" or on account of having some historical connection with the source of Rhubarb.

Of the varieties of Rhubarb there is but little useful to say, as they are often distinctions without a difference, since they are named, not from the species of Rheum, often not even from the places where they are collected, but from the towns or markets whence exported to Europe. "Turkey Rhubarb," exported through Asia Minor, has long since been obsolete; so is the so-called Turkey (Russian) Rhubarb of modern times. Both had their origin, like the present supply, in China or Thibet. Indian and Chinese Rhubarbs are spoken of now, but they have no essential differences, and are probably all Chinese in their origin. European Rhubarb (see below) is a distinct product, from *R. Rhaponticum*.

History.—Rhubarb has been used in China from the remotest ages (2700 B.C., Flückiger), and possible references to it are found in the earliest European books on medicine. As early as the seventh century of our era, there can be no doubt of its occurrence in Europe, and by the tenth or eleventh it was well known and highly valued. It was always, until recently, an expensive drug, on account of the long transportation required to bring it to market. One of the earliest routes was westward along the wastes of Central Asia, through the Caspian region to the Black Sea, or Asia Minor. It was long ago imported, too, by water from India as now, or rather around the Cape of Good Hope, and came in other ways, partly by land and partly by sea, through Persia or Egypt. For the past two hundred years traffic between China and Russia, through Siberia, has permitted this drug to be brought, by a long and painful route, to Europe through that country, terminating in Moscow. For about a hundred years previous to 1860 the Russian Government monopolized the Rhubarb trade between Siberia and the Chinese provinces, and established an exceedingly strict inspection of all the roots exported that way, condemning and destroying all but what was absolutely perfect. In this way an exceptionally fine quality was obtained, and exported, after its long hard journey, from Moscow. Curiously, in England and this country the old and entirely inappropriate name "Turkey Rhubarb" was given to this variety. Since 1860 this inspection has been discontinued, and this grade of Rhubarb has entirely disappeared from English and American commerce. The increased facilities of transportation from various Chinese ports, as well as from the whole of Asia, have also drawn the course of transportation southward.

Of the collection of Rhubarb but little detail is known. Several travellers have seen it in one district or another, and described it in general. The roots are dug, sometimes at least, in the fall, the larger ones and the root-stocks only being taken, and these are dried, according to some, by artificial heat; according to other reports, by the sun alone. That some pieces are strung upon cords to dry is evident enough; also that the roots are in some way deprived of their outer surface. The old Russian Rhubarb

showed the marks of the knife where it was peeled in good-sized slices, but the present Chinese pieces are all smooth and rounded, as if finely filed or scraped into shape after drying, or possibly smoothed by the attrition of long transportation.

DESCRIPTION.—Chinese Rhubarb is met with in pieces of various sizes and shapes, deprived of the cortical layer, having a smooth, rounded, and bright yellow-buff surface, evidently finally prepared after the root has dried. The most common form is cylindrical or barrel-shaped, as the roots, up to four or five centimetres in diameter, appear to be generally dried without splitting; larger than this they are cut longitudinally, and "flat Rhubarb" is the result. Besides these pretty uniform shapes, it is sometimes quite irregular. A small hole near one end, with its margins somewhat discolored, is usually present, and shows that the pieces are strung in rows to dry; bits of string are also frequently found in these perforations. Rhubarb is usually very clean and carefully sorted before it reaches us; even the different shapes and sizes are in some measure packed separately; here it is often again re-sorted, and the choicest-looking pieces are reserved for retailing whole, while the rest is ground, or it may be sawed in little cubes or prisms. The outer surface of regular pieces, where the bark is not too deeply cut away, shows numerous fine, deep orange, lozenge-shaped spots (the ends of the medullary rays), separated by a pretty regular net-work of white lines. These rays, in the interior of the root, are arranged with the greatest irregularity, generally in the cortical zone of the section, having a somewhat radiate tendency, but by no means always obviously. Near the cambium region is an irregular circle of small dark stars (as they appear in transverse section), about two millimetres in diameter, composed of short rays radiating from a point or short axis. Similar stars are seen more sparsely, also, in the interior parts of the root or stem. These stellate markings are only found on the larger pieces, the roots under two centimetres in diameter being wholly without them; but, when present, they serve to distinguish with certainty Chinese Rhubarb from the very much cheaper European sort. Rhubarb, to be of good quality, should be bright in color, glistening and brittle upon fracture, beautifully and clearly veined, and gritty when chewed. It has a bitter, very disagreeable astringent taste, and a peculiar, also disagreeable, aromatic odor.

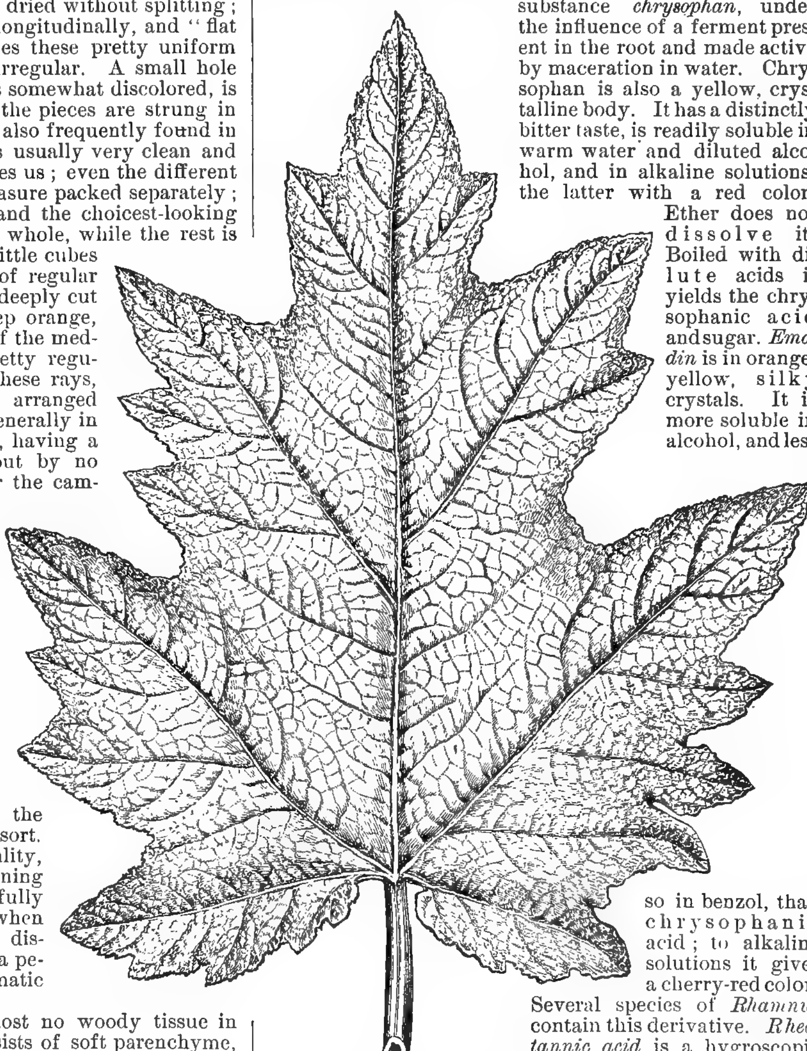

FIG. 3340.—Leaf of Rheum Palmatum; variety, tanguticum. (Baillon.)

COMPOSITION.—There is almost no woody tissue in Rhubarb. The white part consists of soft parenchyme, containing *starch* and crystals of *oxalate* of *lime;* the reddish lines and spots are medullary, and contain the active constituents and coloring matters. Both portions probably contain the mucilage, etc., of which the root has ten or fifteen per cent., as well as albuminoids, and other common plant-substances. No single constituent has been found in this root to represent all its activity, consequently no "active principle" of it is in the market, although one or two of the substances named below can be obtained of the chemists. Indeed, the composition of Rhubarb is still in many respects very obscure. The following list is quoted from M. I. Schmidt by Huseman, and bears date 1874: *Tannin*, 2.106 per cent.; *phæoretin*, 0.65; *chrysophan*, 0.05; *chrysophanic* acid, 4.70; emodin, 0.50; ash, 12.15. Of these one of the most important is *chrysophanic acid*. This is an orange-yellow compound, crystallizing in needles or six-sided prisms; it is without taste or smell, and can be partially sublimed. Cold water dissolves almost none of it; hot water dissolves a little, making a yellow solution. It is more soluble in alcohol, ether, etc., and in some acid and alkaline solutions. Chrysophanic acid is not peculiar to Rhubarb, but is also found in other species of *Rheum*, in the docks (*Rumex*), as well as in *Parmelia parietina* Ash, and other lichens. The chrysarobin of Goa is a related product. Although this acid is easily obtained from Rhubarb, according to Professor Kubli, it does not exist in the root, but is the result of a glucoside decomposition of the next substance *chrysophan*, under the influence of a ferment present in the root and made active by maceration in water. Chrysophan is also a yellow, crystalline body. It has a distinctly bitter taste, is readily soluble in warm water and diluted alcohol, and in alkaline solutions, the latter with a red color. Ether does not dissolve it. Boiled with dilute acids it yields the chrysophanic acid and sugar. *Emodin* is in orange-yellow, silky crystals. It is more soluble in alcohol, and less so in benzol, than chrysophanic acid; to alkaline solutions it gives a cherry-red color. Several species of *Rhamnus* contain this derivative. *Rheotannic acid* is a hygroscopic yellow powder of astringent taste, reducing iron with a greenish-black color; it dissolves readily in water and spirit, and precipitates mucus and albumen. *Phæoretin*, as well as *aporetin*, *erythroretin*, is a not very well-defined resinous substance, existing only in minute quantity. The composition of Rhubarb, as at present known, does not give much clew to its quality.

ACTION AND USE.—When chewed Rhubarb stimulates the saliva. In small doses, in the stomach, it seems to act as a digestive stimulant; in larger ones it appears to be a simple purgative, hastening along the contents of the bowels by increased peristalsis, carrying the liquid contents of the small intestine rapidly down, to soften and force along the more solid mass in the colon and rectum. Intestinal secretion is supposed to be less stimu-

lated by it than by salines or the cathartic resins. Its coloring matters are absorbed, and may tinge the milk and urine. Really our knowledge of the details of the action of this, and many other vegetable cathartics, is much more vague than is desirable. Their gross action is evident enough, and the comparative liability to produce nausea, vomiting, colic, collapse, etc., is pretty well understood; but how much is peristalsis, how much retarded absorption, how much increased secretion, how much biliary stimulation, is known of very few. Rhubarb is mild and pretty certain; it produces comparatively little pain, no depression in moderate doses, and its action is not prolonged. The tannin in it is credited with producing some constipation after its use, but the simple emptying of the bowels without irritation of the mucous membrane would be enough to explain this result. Rhubarb is given in almost all conditions where simply emptying the bowels is desired.

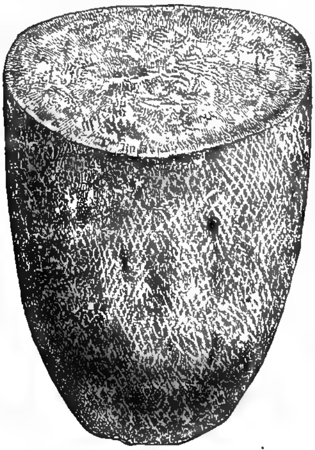

FIG. 3341.—Piece of Round Chinese Rhubarb, showing the white lozenge-shaped reticulation on its surface and the irregular medullary rays on the section. (Baillon.)

ADMINISTRATION.—Rhubarb is offered by the Pharmacopœia in a great variety of forms; it is also found in a good many of the popular proprietary laxative mixtures. It makes a fine, deep-yellow powder which is sometimes given, but not often, on account of its very nauseous taste. Two or three decigrams (gr. iij. ad v.), once or twice a day, would be a very mild tonic-laxative dose; a single dose of a gram (gr. xv.) is mildly, while one of two grams (gr. xxx.) would be severely, cathartic. Rhubarb in substance is frequently taken by chewing and swallowing a piece of the root as large as a pea or a bean, once a day or so, preferably after eating; the taste in this way being less nauseous than that of the powder. The tonic, almost carminative, action of Rhubarb upon digestion, has made it widely used in this way. The following are the preparations of the U. S. Pharmacopœia:

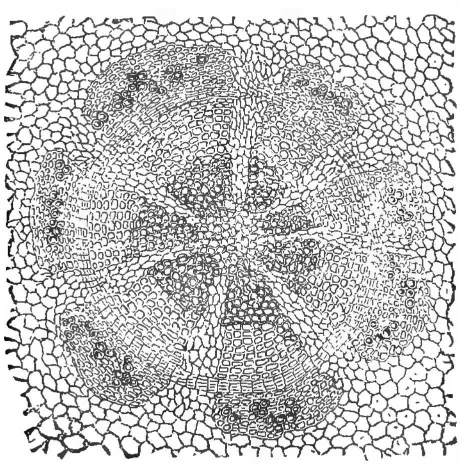

FIG. 3342.—One of the "Stars" of the Cambium Zone; magnified. (Baillon.)

Extract (*Extractum Rhei*), made by exhausting with alcohol and water, and evaporating; strength about $\frac{4}{1}$; useful for pills and mixing with other pill-masses.

Fluid Extract (*Extractum Rhei Fluidum*), strength, $\frac{1}{1}$, less used than the tinctures, is an ingredient of the following:

Mixture of Rhubarb and Soda (*Mistura Rhei et Sodæ*):

Bicarbonate of Soda	30 parts.
Fluid Extract of Rhubarb	30 "
Spirit of Peppermint	30 "
Water enough to make	1,000 "

It is an excellent laxative for indigestion, or diarrhœa with fermenting intestinal contents.

Pills (*Pilulæ Rhei*): Rhubarb, three parts; soap, one part; each pill contains three grains of Rhubarb.

Compound Pills of Rhubarb (*Pilulæ Rhei Compositæ*): Rhubarb, two grains; Purified Aloes, one and a half grain; Myrrh, one grain; Oil of Peppermint, one-tenth of a grain, in each pill.

Compound Powder of Rhubarb (*Pulvis Rhei Compositus*): Rhubarb, twenty-five parts; Magnesia, sixty-five parts; Ginger, ten parts. Corresponds to the mixture.

Tincture of Rhubarb (*Tinctura Rhei*), strength, $\frac{12}{100}$, with $\frac{2}{100}$ of Cardamom.

Aromatic Tincture (*Tinctura Rhei Aromatica*) contains:

Rhubarb	20 parts.
Cinnamon	4 "
Cloves	4 "
Nutmeg	2 "

Diluted Alcohol enough to make one hundred parts. The most desirable preparation as a general cathartic.

Sweet Tincture (*Tinctura Rhei Dulcis*):

Rhubarb	8 parts.
Glycyrrhiza	4 "
Anise	4 "
Cardamom	1 "

Diluted Alcohol enough to make one hundred parts. A desirable preparation for children, as the licorice masks somewhat the disagreeable taste.

Wine (*Vinum Rhei*), strengh $\frac{1}{10}$, with $\frac{1}{100}$ of calamus in sherry wine, a duplicate of the tincture.

Syrup (*Syrupus Rhei*):

Rhubarb	90 parts.
Cinnamon	18 "
Carbonate of Potassium	6 "
Sugar	600 "

Water enough to make one thousand parts. Like the sweet tincture, the sirup is a very popular cathartic for infants and children.

ALLIED PLANTS.—The genus contains about twenty species, most of whose roots have qualities similar to the above. Several of these, *R. Rhaponticum*, and others, are cultivated in Austria and elsewhere in Europe for this

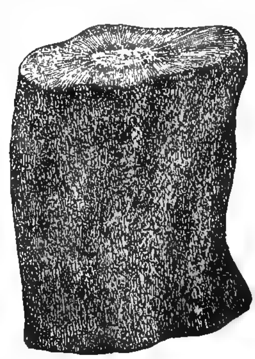

FIG. 3343.—European Rhubarb. (Flückiger.)

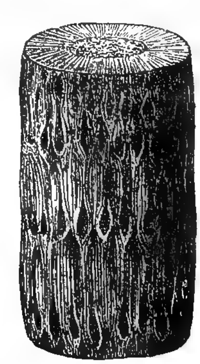

FIG. 3344.—European Rhubarb. (Flückiger.)

purpose, and the European product is trimmed and prepared so as to closely imitate the Chinese. It can generally be told by its duller color, more spongy texture, absence of gritty crystals when chewed, and the more regular arrangement of its medullary rays; the stellate

spots are absent. The foliage of Rhubarbs is bitter and sour; by cultivation the above and several other species have developed very large and pleasantly acid petioles, which, especially if partially blanched or shaded, make a delicious vegetable for tarts and stews. Malic and oxalic acids and their salts, and nitrate of potassium, are among their constituents.

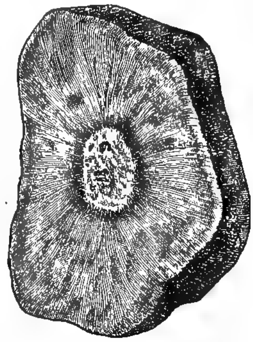

Fig. 3345.—European Rhubarb; surface of a transverse section. (Flückiger.)

The order contains besides: Bistort, *Polygonum Bistorta* Tourn; Buckwheat, *Fagopyrum esculentum* Mönch; Docks and Sorrels, *Rumex sp. var.* These latter (docks) resemble Rhubarb somewhat in the composition of their roots, but as their tannic matters are in excess of their laxative ones, they are not cathartic.

Allied Drugs.—The different species of *Rhamnus* (Buckthorn, Cascara Sagrada, Frangula, etc.) appear, in their action on the bowels, and, in some respects, in composition, to be more like Rhubarb than most cathartics. Senna, Wahoo, Blue Flag, and Podophyllin in small doses may also be mentioned, as well as perhaps Castor-oil. Aloes acts more upon the large intestine, the drastics and salines are more depressing, hydragogue, and violent. Sulphur and Magnesia are less active, but not dissimilar in kind to Rhubarb. None of them has the later astringent effect of the one under consideration.

The following list of substances used to increase the movements of the bowels, partly from Brunton, appears to be very well arranged:

Laxatives: Honey, Molasses (and food made with it), Manna, Cassia Fistula, Tamarinds, Figs, Prunes, Stewed Apples, Sulphur, Magnesia.

Simple Purgatives: Aloes (?), Rhubarb, Senna, Frangula U. S., Cascara Sagrada, Castor-oil, etc.; also Calomel (single dose).

Drastics: Elaterin, Colocynth, Jalap, Scammony, Gamboge, Podophyllin, Croton-oil.

Salines: Sulphate of Soda, Sulphate of Magnesia, Phosphate of Soda, Tartrate of Potassium, Bitartrate of Potassium (very mild), Citrate of Magnesium.

Cholagogues: Aloes, Rhubarb, Mercury (various preparations), Enonymin, Iridin, Podophyllin.

W. P. Bolles.

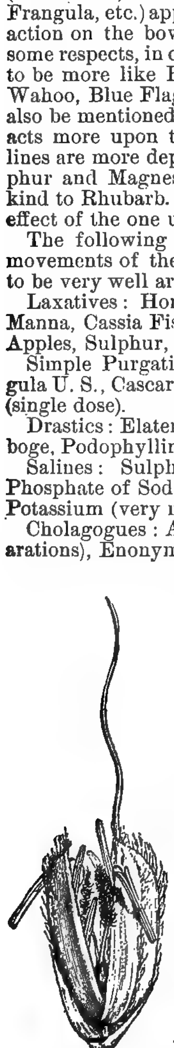

Fig. 3346.—Flower of Rice. (Baillon.)

RICE (*Riz*, Codex Med.). The grain of *Oriza sativa* Linn., Order, *Gramineæ*. A water- or swamp-grass originally from India, cultivated there for ages, early introduced into Southern Europe and the warmer parts of America, and forming the principal food-product of many tropical races of men. It has been divided into numerous garden varieties differing in the length of its glumes, color, size, and shape of its grains, etc.

For use, the grains are deprived of their husks and pericarps by beating, rubbing, or passing between rollers, by which means the embryo also is shelled, or rubbed out. The prepared grain, consisting entirely of the perisperm, needs no description. It has a smaller amount of mineral and albuminous constituents than other cereals, and a larger amount of *starch* (eighty-five to ninety per cent.). Rice starch is also a commercial product; it consists of exceedingly minute polyhedral granules. (See Starch.)

Rice has no medicinal properties, it is simply an almost pure farinaceous food, and is neutral and unirritating to the bowels; on this latter account it is often given in dysentery and diarrhœa. Rice-water, made like barley-water, by boiling whole rice in a large proportion of water and pouring off the clear liquid, contains a little soluble starch, and is employed as a demulcent drink.

Allied Plants, etc., see Starch. *W. P. Bolles.*

RICHFIELD SPRINGS. *Location and Post-office*, Richfield Springs, Otsego County, N. Y.

Access.—By the New York Central & Hudson River, the New York, West Shore & Buffalo, and the Delaware & Lackawanna Railroads.

Analysis (Professor C. F. Chandler).—One gallon contains:

	Grains.
Hydrosulphate of sodium	1.7189
Hydrosulphate of calcium	0.0908
Sulphate of potassa	1.6656
Sulphate of lime	112.3379
Sulphate of strontia	0.0105
Sulphate of barium	trace
Sulphate of magnesia	5.1498
Hydrosulphite of soda	0.3801
Bicarbonate of magnesia	31.7403
Bicarbonate of iron	trace
Phosphate of lime	0.0067
Chloride of sodium	0.5249
Chloride of lithium	0.0165
Alumina	trace
Silica	0.6415
Total	154.2835
Gas.	Cubic inches.
Sulphuretted hydrogen	14.206

The above analysis is of the water of "The Great White Sulphur Spring."

Therapeutic Properties.—These well-known sulphur waters are among the best of their class. The picturesque situation and classical associations add materially to the popularity of the resort. The diseases for which these waters are famous are chronic catarrhs, rheumatism, and skin affections.

Richfield Springs is situated about sixty miles west from Albany, on Canaderaga Lake, at an altitude of seventeen hundred feet. The surrounding country is devoted to farming, and affords many beautiful drives, especially about Otsego Lake, five miles distant, famous as the scene of some of Cooper's "Leather-stocking Tales." The hotel accommodations are first-class and ample. Of late years Richfield has become a favorite and popular summer resort. *George B. Fowler.*

RICKETS. Syn.: Rachitis; Fr., *Nouure, Rachitisme;* Ger., *Englische Krankheit.* A disease of childhood, arising from perverted nutrition, affecting nearly every tissue of the body, but chiefly and most constantly characterized by a softening of the bones, with resulting deformities. It occurs most frequently in children under three years of age, the greater number of cases apparently originating during the second year of life, at the period when weaning is usually accomplished; and though the bone symptoms may make their appearance at a later period than the end of the third year, careful inquiry will generally establish the fact of the occurrence of some of the manifestations of the disease in earlier life.

The *etiology* of rickets is obscure. It is usually supposed to be due to insufficient or improper food and impure air. Yet, though of undoubted importance, these are not the sole factors in the causation of this disease; for of the thousands of children living in the crowded tenements of our cities, constantly inhaling a vitiated atmosphere, and seldom receiving proper nourishment, but few, comparatively, are the subjects of rickets. On the other hand, the children of well-to-do parents, living under vastly better hygienic conditions, are by no means exempt.

Parrot advanced the theory that rachitis is a development of hereditary syphilis; but he stood almost alone in this view, and since his death the theory has had few supporters. Fournier, indeed, asserts that rachitis is so frequent among children the subjects of hereditary syphilis, that there must be some relation between the two

affections. He believes that syphilis may act indirectly as a cause by producing malnutrition. But this is very different from the theory of Parrot, who believed that hereditary syphilis was the sole cause of rickets; that rickets, indeed, *was* hereditary syphilis. In the "Report of the Collective Investigation Committee of the Norwegian Medical Association" (Christiania, 1887) it is stated that, out of two hundred and forty-two cases of rickets, it was possible to find some evidences of syphilis in the parents in only nine instances.

Oppenheimer assumes the disease to be a manifestation of malarial poisoning, basing his belief upon the periodicity that has been frequently observed in some of the symptoms. He states that rickets occurs chiefly in localities in which malaria is most prevalent; but this assertion is not borne out by observation, for the disease is of greatest frequency in cities, where malaria is weakest, and is very rare in tropical regions, where the most pernicious forms of malaria prevail.

It has been asserted that the children of young parents are more often rachitic than those of older parents, but the writer has been unable to verify this assertion by a study of the statistics at his command.

The influence of heredity has been denied. It is an undeniable fact that the mothers of rachitic children often themselves show evident traces of the disease, but this may possibly be ascribed to the fact that they were brought up under similar conditions. That there is, however, at least a racial predisposition to rachitis, is a fact of daily observation. In this country the disease is seen for the most part in children of parents born in European countries, with the exception possibly of the Irish, among whom it would seem to be for some reason less common than among those of the Anglo-Saxon and Latin races. The children of white native Americans are comparatively seldom attacked, but negroes are almost without exception rachitic. This predisposition to rickets in the colored race would seem to be an acquired one, for it is said that native Africans seldom, if ever, show any evidences of the disease.

The first symptoms are often developed during convalescence from whooping-cough or some other of the debilitating diseases of childhood. In the present state of our knowledge the most that can be said is that rickets is a disease occurring in children predisposed by hereditary or racial influences, in whom the assimilative functions have become impaired by poor food, bad air, absence of sunlight, or the influence of debilitating disease.

Pathology.—Of the pathology of rickets even less is known definitely than of its etiology. Numerous theories have been advanced, most of which are, however, based solely upon the changes observed in the bony structures, leaving out of consideration the pathological processes occurring in other tissues.

The urine in this disease contains an excess of phosphates, while the bones are markedly deficient in earthy constituents; and upon this fact is based the theory of an increased formation of acid in the system, whereby the earthy materials are dissolved out of the osseous structures. The nature of this acid, however, has never been determined, and its existence even remains a matter of conjecture only.

The changes occurring in the bones are much too complicated and varied to admit of a purely chemical explanation. The new bone formed beneath the periosteum is soft and deficient in earthy matter, and the animal matter seems also to be abnormal, as it has been found by some observers not to yield gelatine on boiling. The epiphyses are enlarged, and ossification at these points proceeds slowly and with great irregularity. The border of ossification does not present a clearly defined, straight line, as in normal bone, but is serrated, the new bone shooting far up into the cartilage in some places, while at other points streaks of unossified cartilage are observed extending for some distance along the shaft of the bone. The medullary cavity is advanced beyond the border of ossification, and is filled with a reddish pulpy matter. The lamellæ of bone are loosely imposed one upon the other, so that sometimes, in fresh specimens, they may be peeled off like the layers of an onion. Spontaneous incomplete fractures not infrequently occur, giving rise to much of the deformity usually attributed to a simple bending of the bone. Separation at the epiphysis (diastasis) may also take place, and when occurring at the hip may simulate congenital dislocation.

Ossification in the flat bones proceeds in the same irregular manner. In the cranium the fontanelles remain open for a long time, the sutures are not firmly united, and are apparently depressed, owing to an elevation along the borders of the bones similar to the enlarged epiphyses of the long bones. The earthy matter is not deposited regularly, but here and there soft spots may be felt in which the osseous formation is wanting. This deficiency is most common in the occipital bone, and constitutes the condition known as craniotabes.

The liver, spleen, and lymphatic glands are frequently enlarged and harder than normal. The brain is often hypertrophied, the change involving chiefly the white substance. The muscles are flabby, poorly developed, and on section seem to be paler than normal. The ligaments are nearly always relaxed.

Symptoms.—The earliest stage of rickets is characterized by no pathognomonic signs, and may readily escape recognition. The only symptoms are those of imperfect nutrition. The appetite is good, but the child does not seem to thrive. It is a little peevish and out of sorts, and the usual means resorted to by the mother or nurse to restore good nature are unavailing. It is most contented when alone, and resents any playful overtures, especially objecting to being tossed in the air or trotted upon the knee, sports which perhaps occasioned delight at an earlier period of its existence. Growth is retarded, the rounded cheeks and plump limbs lose their chubby outlines, and the child looks puny and wizened. Occasional attacks of diarrhœa may alternate with obstinate constipation.

Now the disease is established and its true character becomes revealed. The desire to be let alone becomes more positive, and is due to a hyperæsthesia of the skin, so that even a light touch may cause actual pain. The little patient will lie quietly for hours in its crib if undisturbed, but cries and betrays apprehension upon the mere approach of anyone who, it fears, is about to lift it. The weight of the bedclothes even seems to cause pain or discomfort, and, perhaps in consequence of this, the child is found uncovered as often as it is visited by the mother or nurse. There is profuse sweating, especially about the head, to such a degree oftentimes that the pillow is soaked by the perspiration. The action of the bowels is irregular, and attacks of diarrhœa with very offensive stools frequently occur.

The muscles become soft and flabby. Some writers speak of a rachitic paralysis, but this is incorrect; the muscles are weak and often atrophied, but the atrophy is rather that of disuse, and no real paralysis exists. The ligaments are relaxed, and the joints are in consequence abnormally movable. The child makes no attempts to walk or stand, but cries if placed upon its feet. Sometimes it is even unable to sit up; the back is bowed, and the head lolls from side to side, the patient having no power to steady it.

The teeth appear late and at irregular intervals; they are poorly formed, and early become carious.

There is but little, if any, elevation of temperature. The appetite usually is good, sometimes excessive, and thirst is a fairly constant symptom.

The picture here presented is that of the early stage of typical severe rachitis, prior to, and during the commencement of, the stage of softening of the osseous tissues. The symptoms vary greatly in severity, sometimes being so slight as to escape remark by the mother; but careful questioning will usually elicit the admission that the child was noticed to perspire freely, and that it had a habit of constantly throwing off the bedclothes. The most painstaking investigation will not seldom fail to develop any fuller history than this.

The second stage is that of softening of the bones, through which many of the characteristic deformities of

rickets are produced. All the bones of the body are subject to this change, though, in mild cases, the deformity is chiefly confined to the lower extremities, which become bent under the weight of the body. It is probable, also, that the muscles have some part in the production of the deformity in the long bones. But the more common occurrence of distortion in the lower extremities is seemingly due to the fact that these members have to bear the weight of the body. The upper extremities are less often bent, and when they are curved to any extent it is generally because the child has been allowed to crawl, thus throwing some of the weight on the arms. During this period the symptoms of the first stage usually continue, though with decreasing severity; or, in the milder cases, a marked amelioration may take place; the muscles regain their strength, the ligaments grow less yielding, the outlines of the limbs become rounded, and the child gains rapidly in weight. But this improvement in the general health has its disadvantage in causing increased deformity of the lower extremities, by forcing them to sustain a greater weight while the bones are still more or less yielding.

The head, in a typical case of rachitis, is elongated, and flattened upon the top and at the sides, the occiput is projecting, and the frontal bosses are prominent, thus giving to the head, when viewed from above, a rectangular appearance (*tête carrée*, caput quadratum). The features are small, and the cranium in consequence appears to be greatly enlarged, when it really may be smaller than normal. Dr. Henry N. Read (*New York Medical Journal,* August 29, 1885) states that the ratio of the greatest antero-posterior diameter to the base-line of the cranium is altered. Normally this should be, as pointed out by Dr. Samuel Gee, as 6 : 5. But in rickets Dr. Read has found that the antero-posterior diameter of the cranium is always lengthened in proportion to the base-line; in a case reported of not very marked rachitis this ratio was as 7+ : 5. There is sometimes an actual increase in size, due to hydrocephalus. The fontanelles are open, the sutures loosely knit, and lying in a groove caused by the prominent edges of the bones on either side. The soft spots in the occipital bone, due to imperfect ossification, may sometimes be felt. This condition (craniotabes) is said to be one of the earliest and most constant anatomical features of rachitis. The writer has not, however, found it with anything approaching the constancy asserted of it by most authors.

The ligaments and muscles of the spine are weak, the bodies and intervertebral cartilages are soft, and the consequent deformity is a posterior curve (kyphosis) in the dorsal region, with at times compensatory lordosis of the cervical and lumbar portions; usually, however, the kyphosis is complete and involves the entire length of the spinal column. Lateral curvature, or scoliosis, due to rickets, is a much less common deformity than kyphosis, though it is by no means rare.

The scapula usually suffers but little change; sometimes it is thickened, but more often is smaller than normal. The clavicle is thickened, its articular ends are enlarged, and it presents an exaggeration of its normal curves. Deformity of the arm and forearm, when at all pronounced, is found generally in children who cannot walk, but crawl upon their hands and knees. The curve of the humerus is outward, with its greatest convexity at the point of insertion of the deltoid muscle. The convexity of the curve of the forearm shows itself on the dorsal aspect. A very constant sign of rachitis, even in slightly marked cases, is the enlargement of the epiphyses at the wrist, the swelling being the more readily appreciated here because of its superficial location.

The softening of the ribs, when marked, is a constant source of danger, owing to the impediment thereby offered to free respiration. The heart is also very constantly hypertrophied in marked cases, in which the softening of the chest-walls is pronounced. The thorax is bulging at the sides, but the ribs recede before uniting with their cartilages, forming a groove running from above downward and inward on each side of the anterior wall of the chest. Each rib is enlarged at its junction with the cartilage, forming a row of knobs just anterior to the depressed line, and which has been called the rachitic rosary. The sternum projects forward in fancied resemblance to the keel of a ship, or the breast-bone of a fowl (pectus carinatum, chicken-breast). The lower ribs are flaring, being pushed out by the enlarged liver and spleen. The abdomen is swollen from the same cause, and also from flatulent distention of the bowels, which occasions much suffering to the little patient.

The deformity of the pelvis in the female may prove a serious obstacle to parturition in later life. The sacrum projects forward, and the acetabula are pushed in by the weight of the trunk; a horizontal section of the true pelvis thus presents the appearance of a trefoil.

The neck of the femur forms a more nearly right angle with the shaft than is normal; the latter is bowed outward and forward. The deformity sometimes consists of a sharp curve, with the concavity looking outward, at the lower end of the femur, producing one form of knock-knee; the tibia also sometimes presents a bend at its upper part, similar to that of the lower end of the femur, which contributes to produce the same deformity. Bow-legs is caused by an outward curve of the tibia, or of the tibia and femur, associated usually with a relaxed condition of the lateral and crucial ligaments of the knee. The tibia not infrequently presents an anterior curve at its lower third. The fibula usually follows the curve of the tibia, though in rare cases it may remain straight, in which case the external malleolus will project too low down and cause pain and difficulty in walking. The malleoli are enlarged and prominent. Flat foot (talipes valgus) frequently results from stretching of the plantar fascia, with consequent breaking down of the arch of the foot, and also from softening of the bones of the tarsus.

The chief cause of the deformities in rickets is the weight of the body acting upon the long bones of the extremities and causing them to bend or break; not infrequently the curves are due to a green-stick fracture rather than to a simple bowing. Muscular action is, however, a frequent, and sometimes the sole, factor in the production of deformity. The misshapen thorax is a result of atmospheric pressure and muscular contraction combined.

The last stage of rickets is the stage of cure. The constitutional disturbances, in cases in which they have continued through the second stage, now subside, and the child seems again to enjoy the perfect performance of all the animal functions. The bones become firm from a deposition of the earthy constituents, but there is not a simple restoration of the osseous structures to the normal; for, with the irregularity peculiar to rickets, in which the balance-wheel of the animal machine seems to be wanting, there is an excess of action; the process of ossification, so long delayed, now runs wild, and the soft animal matter becomes converted into ivory rather than bone. Any deformities which have been overtaken by this process, called eburnation, while still uncorrected, become fixed and incapable of cure by other than operative measures.

Sometimes a spontaneous straightening of the bowed limbs occurs during this stage. This occurrence is difficult of explanation, but it is possibly due to an increased growth on the concave side of the bone.

A child who has been profoundly affected with rickets never attains the full stature which he would have reached had he remained free from the disease. In a given family, the children who have suffered from rickets, even though they be free from deformity, are always shorter than their unaffected brothers and sisters.

The *prognosis* of rachitis, apart from its complications, is favorable as regards life; very few children die from rickets alone, but many succumb to bronchitis and laryngismus stridulus, appearing as complications of the disease. A simple bronchitis, which would pass almost unnoticed in a healthy child, becomes a most serious disease in one affected with rickets, in whom the ribs are soft and yielding. The elasticity of the thoracic walls is impaired, the lungs can neither receive nor expel a normal amount of air, and when a further impediment is added to respi-

ration by the presence of inflammatory secretions, the condition of the child becomes precarious indeed.

Another complication, through which the life of the child is jeopardized, is laryngismus stridulus. This affection is stated by some writers to occur only as a consequence of rickets, the origin of each attack being attributed to cerebral pressure from the weight of the softened cranium resting upon the brain. It certainly occurs most frequently, if not solely, in rachitic children.

The prognosis, as regards deformity, if mechanical treatment be neglected, is unfavorable. The curved bones, it is true, do at times straighten themselves as the disease subsides, but such a favorable result is doubtful, and can seldom be predicated in any individual case. But little can be done by way of prevention of the pelvic deformity, the consequences of which in after-life, in females, are often most serious. A spontaneous rectification of this deformity seldom, if ever, occurs. Fortunately it is of rare occurrence, except in the most severe forms of the disease.

The *treatment* of rachitis is twofold, viz., the treatment of the disease, and the prevention or correction of deformity. All measures which tend to improve nutrition are beneficial. Light and airy sleeping apartments, easily digestible and not too watery food, pure mountain or sea air, plenty of sunlight, perfect cleanliness, all are of the utmost importance. A change should always be sought; if the child live near the sea, mountain air is more likely to be of benefit, and conversely, those from inland towns should be taken to the sea-shore. Salt-water baths, in moderation, sometimes prove in the highest degree beneficial. Unfortunately, the children of the poor, living in the crowded quarters of large cities, are seldom able to avail themselves of such treatment. Yet much may be done, even here, by a more careful observance of some of the simplest rules of hygiene, to give instruction in which is the first duty of the medical attendant. The child may be taken every day, or every other day, to the parks or outskirts of the city; or, if the town is by a river, to the water's edge or upon a ferry-boat. If the parents live on the first floor of a tenement-house, they should seek rooms on the upper floors, where the air is presumably less impure. Great care should be taken in guarding against the sudden changes of our climate, since even a slight bronchitis is liable to prove fatal. As these children always lie uncovered, in spite of the most watchful care, they should sleep in flannel garments which cannot be thrown off. Cod-liver oil and the compound syrup of the hypophosphites are useful when they are not rejected by the stomach; they may be administered in combination, or the oil may be given in winter, and the hypophosphites in summer. Eucalyptus globulus, in doses of ten to forty minims of the tincture, three or four times a day, is said to be often very beneficial.

Much has been written of late years for and against the use of phosphorus, as recommended by Kassowitz, in the treatment of rachitis. Many regard this drug as a real specific in rickets, while others, after a long experience, condemn it as useless, if not harmful. The writer's experience with it has not been sufficiently extensive to warrant him in expressing a positive opinion. But in some dozen cases in which he has tried it, it has seemed to be of service. No bad effects were observed. The dose is $\frac{1}{500}$ to $\frac{1}{200}$ grain twice or three times a day. The phosphorus should not be given dissolved in cod-liver oil, as recommended by some, for such a mixture is not permanent, and soon becomes inert. The ethereal solution and the solution in bisulphide of carbon are probably the best forms in which to administer it. The latter may be prepared after Hasterlik's formula as follows:

℞.	Phosphori	0.01 (gr. $\frac{1}{6}$).
	Carbonei bisulphidi	0.25 (gr. iv.).
	Aquæ destillatæ	100.00 (℥ iij.).
M.		

The dose of this is half a teaspoonful, which may be given in syrup, or, preferably, with an equal amount of cod-liver oil. The solution should be kept in a well-stoppered bottle away from the light.

Treatment of the deformities should be instituted early, before the bones become hard, and should be persevered in without intermission. The mechanical treatment of rachitis is no less important than the hygienic and medicinal, and in no case should it ever be neglected under the idea that the deformities will correct themselves. No child who has received intelligent instrumental treatment need grow up with crooked legs or a crooked spine as a result of rickets, and every adult who suffers from such misfortune is a living witness of parental or medical neglect. For the management of the special deformities, see under their respective headings.

Thomas L. Stedman.

RIO DE JANEIRO. The accompaning chart, representing the climate of the city of Rio de Janeiro, Brazil, is likely to interest some of the readers of the REFERENCE HANDBOOK, as giving them a fairly typical showing of a truly tropical climate (although, to be sure, not an extreme example of this class), and also as conveying more accurate information than is generally possessed respecting the climate of the largest commercial city of the South American continent. As a health-resort proper, Rio de Janeiro is not for a moment to be considered; but as a temporary halting-place for invalids undertaking a long sea voyage it is worthy of consideration. A knowledge of its climate will also be of service to such business men as are, by the necessities of their calling, compelled or prompted to make this city a place of more or less permanent residence.

Foreigners, whenever possible, would do well, however, to make some one of the higher-lying towns of Brazil, situated at no great distance from Rio, their place of residence, at least during the warmer months, in order to escape the continuous heat and great atmospheric humidity which combine to make the climate of the city itself so debilitating. The German colonies of Petropolis and Novo Friborgo may be specified as good places of resort at this season. Petropolis is but two and a half hours' distant from Rio, and Mr. C. C. Andrews, in his work on Brazil, tells us that "a few business men make the round trip daily." Novo Friborgo lies one hundred and twenty miles to the northeast of Rio. For an interesting account of the climatic conditions prevailing at the last mentioned of these two places, see the London *Lancet* of July 19, 1884. The high ground immediately back of the city will also be found more comfortable and more agreeable as a place of residence than the low-lying and thickly built business portion of the town.

Yellow fever, which was formerly a great scourge at Rio, has become of late years far less prevalent. Smallpox appears to be endemic, as in most, if not all, of the larger cities of South America, and as in many of the large cities of Europe.

The climatic chart of Rio, here published, was very kindly obtained for the writer by his friend, Mr. Charles L. Jacobson, and was prepared by Mr. T. O. Gunton, of Chester, England. The following passage is extracted from Mr. Gunton's letter to Mr. Jacobson enclosing the chart, and dated Lisbon, May 8, 1885: "I have been unable to record the velocity of the wind, as I have no instrument for the purpose. However, the Rio climate may be thus very briefly described: In normal weather there blows a mere light air from the north, which is known as the land-breeze; then at 1 P.M., or thereabout, springs up the sea-breeze; a fresh breeze from the south and southeast (part of the trade-winds from southeast), lasting until about four or five o'clock, when it dies down, and the nights are usually calm and quiet. Only at periods of change of moon is this weather upset by an occasional sou'wester, when heavy rains are preceded by violent gusts of wind which develop into dust-storms, and then comes rain, heavy weather out at sea, which lasts two or three days; then the weather takes up again until next time.

"The figures are my own, except the rainfall, which was given me in millimetres, and I converted the figures into inches on the .03937 ratio."

In conclusion, the reader's attention is called to the fact

Climate of Rio de Janeiro.—Latitude 25° 54′ 23″ *S.; Longitude* 43° 8′ 34″ *W.—Period of Observations, January* 1, 1884, *to December* 31, 1884.—*Elevation of Place of Observation above the Sea-level,* 327 *feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	1 P.M. Degrees.	10 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	74.89	78.13	75.05	76.02	85.02	68.82	79.21	73.00	95.18	74.30	78.26	64.58	16	14
February...	75.52	81.03	76.51	77.68	83.12	70.10	81.03	74.76	95.54	74.12	77.00	63.50	11	12
March	75.18	79.41	76.83	77.14	81.48	73.86	79.80	74.60	91.94	78.26	77.00	66.38	16	16
April	71.72	77.52	73.76	74.33	84.66	67.78	77.52	71.43	92.30	70.70	74.66	62.60	15	13
May........	68.25	73.67	70.70	70.87	76.53	63.68	73.67	68.09	85.28	68.54	72.50	58.10	12	14
June	66.97	72.41	69.89	69.75	74.98	64.14	72.41	66.97	82.94	66.74	69.62	59.54	15	13
July........	65.69	70.97	67.78	68.14	71.07	65.12	70.97	65.53	79.34	69.80	67.10	59.18	16	0
August.....	63.93	68.55	65.58	66.02	72.26	61.32	68.55	63.19	82.94	64.40	66.02	55.22	17	14
September..	67.37	71.92	69.31	69.53	76.08	63.21	71.92	66.83	86.54	64.76	68.00	61.70	13	10
October	69.89	72.30	69.89	70.69	82.23	64.81	73.34	67.94	92.30	68.54	71.78	60.80	15	13
November..	72.69	74.93	72.71	73.44	86.77	64.40	74.93	70.62	99.50	66.20	76.82	60.80	18	13
December..	74.28	78.00	74.67	75.65	83.84	69.99	78.00	72.46	98.06	72.14	75.38	64.94	13	15
Spring*	......	......	......	67.89	......	......	......	......	......	......	......	......	......	......
Summer† ..	......	......	......	73.26	......	......	......	......	......	......	......	......	......	......
Autumn‡ ..	......	......	......	76.94	......	......	......	......	......	......	......	......	......	......
Winter §....	......	......	......	72.98	......	......	......	......	......	......	......	......	......	......
Year	......	......	......	72.43	......	......	......	......	......	......	......	......	......	......

	J	K	L	M	N
	Range of temperature for period.	Mean relative humidity.	Number of fair days.	Total rainfall in inches.	Prevailing direction of wind.
					From
January	30.60	80.6	20	7.39	N.W.
February	32.04	82.8	15	6.65	E.
March	25.56	79.6	24	6.46	N.E.
April	29.70	78.4	20	14.74	S.W.
May	27.18	77.3	22	1.20	N.E.
June	23.40	79.9	26	0.51	E.
July	20.16	77.1	24	1.12	N.E.
August	27.72	79.7	20	3.37	S.E.
September	24.84	82.3	22	2.57	N.N.E.
October	31.50	79.4	19	3.07	E.
November	38.70	77.8	22	5.96	E.
December	33.12	80.7	20	4.09	E.
Spring*	31.32	79.7	66	7.06	N.N.W.
Summer†	38.70	79.3	61	13.12	E.
Autumn‡	32.04	81.0	68	20.50	N.N.E.
Winter §	34.20	78.5	59	16.45	E.
Year	44.28	79.6	254	57.13	N.N.E.

* July to September. † October to December.
‡ January to March. § April to June.

that the term "fair," as employed in column L, is not to be interpreted in the technical sense adopted by the United States Signal Service, and explained in the general article on climate (vol. ii., page 191), but is rather to be understood in the equally technical sense in which this term is used by English writers, viz., as applying to days on which no actual fall of rain occurs. Moreover, it is to be noticed that the duration of the period of observations upon which are based the data of this Rio chart was but a single year; the bearing of this fact, especially upon the interpretation of columns B, C, and D, is to be borne in mind. All of Mr. Gunton's figures for temperature were given in Centigrade, and have been by me converted into Fahrenheit. *Huntington Richards.*

RIPPOLDSAU is a spa in Baden, in which are four medicinal springs, three of which are employed for internal medication, and one for bathing. The names of the springs are the Badequelle, Wenzelsquelle, Leopoldsquelle, and Josefsquelle. The composition of the last named, according to the analysis of Bunsen, is as follows. One litre contains:

	Grammes.
Calcium bicarbonate	1.6847
Magnesium bicarbonate	0 0707
Ferrous bicarbonate	0.0514
Manganous bicarbonate	0.0043
Sodium sulphate	1.2130
Calcium sulphate	0.0557
Magnesium sulphate	0.2430
Potassium sulphate	0.0605
Magnesium chloride	0.0847
Alumina	0.0044
Silica	0 0572
Arsenic	trace
Total	3.5296

These waters are used chiefly in the treatment of congestive disorders of the abdominal viscera, and in anæmia. *T. L. S.*

RIVIERA. The article describing the Genoese Riviera will be found in the Appendix.

ROANOKE RED SULPHUR SPRINGS. *Location,* Roanoke County, Va. *Post-office,* Roanoke Red Sulphur Springs, via Salem, Roanoke County, Va.

Access.—By the Norfolk & Western Railroad to Salem, thence by stage to the Springs, nine miles.

Analysis (Professor M. B. Harden).—One gallon of 231 cubic inches contains:

	Grains.
Calcium carbonate	6.53650
Magnesium carbonate	5.82876
Lithium carbonate	0.01549
Manganese carbonate	0.01624
Iron carbonate	0.05852
Copper carbonate	trace
Sodium chloride	0.24401
Ammonium chloride	0.01801
Calcium phosphate	0.02931
Lead sulphate	trace
Barium sulphate	trace
Strontium sulphate	1.71000
Calcium sulphate	2.19142
Sodium sulphate	3.03719
Potassium sulphate	0.32626
Sodium hyposulphite	0.03046
Ammonium nitrate	0.05476
Alumina	0.00648
Silica	0.83851
Organic matter	0.76005
Arsenic	trace
	21.70197
Carbonic anhydride combined with monocarbonates to form bicarbonates	5.96680
Total	27.66877
Cubic inches of gas per gallon:	
Carbonic anhydride	12.40
Sulphuretted hydrogen	2.44

THERAPEUTIC PROPERTIES.—These are excellent alkaline, chalybeate, sulphur waters, of a mild and agreeable type.

The springs are situated in the southeastern part of Virginia, at an altitude of over two thousand feet above sea-level. The country is mountainous, with forests of pine, and there are many natural objects of interest within driving distance. The hotel and cottages furnish ample accommodations for two hundred and fifty guests. *G. B. F.*

ROCHEFORT is an important town in France, situated on the Charente River, near its mouth. There is an artesian well here, the water of which, issuing at a temperature of 105° F., is employed, both internally and externally, for therapeutic purposes. The following is its composition, according to an analysis of M. Roux. One litre contains :

	Grammes.
Sodium sulphate	2.590
Calcium sulphate	1.323
Magnesium sulphate	0.504
Sodium chloride	0.754
Magnesium chloride	0.023
Calcium chloride	0.034
Calcium carbonate	0.313
Magnesium carbonate	0.033
Ferrous carbonate	0.035
Alumina	0.005
Silica	0.017
Iodine, bromine, organic matter, etc	0.083
Total	5.714

There are also traces of manganese and arsenic.

This water is employed in the treatment of engorged conditions of the abdominal organs, in anæmia, and in debility during convalescence from acute diseases. Externally it is used to promote the healing of indolent ulcers, to stimulate granulations, and hasten cicatrization. *T. L. S.*

Climate of Rochester, N. Y.—Latitude 43° 8′, *Longitude* 77° 42′.—*Period of Observations, November* 1, 1870, *to December* 31, 1883.—*Elevation of Place of Observation above the Sea-level,* 500 *feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January	22.9	26.4	24.0	24.4	36.5	18.2	30.9	16.9	69.0	39.0	15.0	—12.0	21	29
February	22.6	28.2	24.6	25.1	32.6	14.8	34.1	18.5	63.0	46.0	10.0	—12.0	21	19
March	28.2	34.4	29.7	30.1	40.1	22.2	39.4	24.9	69.0	47.0	16.0	7.0	25	28
April	40.1	47.5	41.2	42.9	52.5	35.5	51.4	35.1	83.5	61.0	35.0	11.0	21	28
May	53.7	62.7	54.2	56.8	64.2	50.1	65.7	46.9	90.0	73.0	34.0	28.0	28	27
June	63.3	71.7	62.8	65.9	69.8	61.0	74.1	55.1	94.0	85.0	48.0	36.0	20	19
July	68.0	77.0	67.8	70.9	74.1	68.2	80.0	62.1	96.0	86.0	54.0	48.0	20	17
August	65.9	75.7	66.6	69.4	73.3	67.1	78.6	60.6	96.0	85.0	54.0	47.0	19	21
September	58.6	67.6	59.4	61.8	71.2	56.2	72.8	55.2	98 0	78.0	46.0	34.0	25	17
October	47.3	55.3	48.7	50.4	57.6	45.6	61.0	44.0	87.0	73.0	36.0	19.0	20	21
November	34.4	39.4	34.9	36.2	40.6	26.6	45.0	31.5	71.0	54.0	25.0	1.0	20	16
December	26.4	29.6	27.4	27.8	36.1	19.5	35.4	23.6	70.0	42.0	16.0	—11.0	20	25
Spring	......	......	......	43.2	49.5	38.7	....	....	......	......	......	......	......	......
Summer	......	......	......	68.7	71.7	66.5	....	....	......	......	......	......	......	......
Autumn	......	......	......	49.4	54.5	44.9	....	....	......	......	......	......	......	......
Winter	......	......	......	25.7	32.6	20.4	....	....	......	......	......	......	......	......
Year	......	......	......	46.8	49.6	43.9	....	....	......	......	......	......	......	.....

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind, in miles, per hour.
						Inches.	From	
January	81.0	80.1	8.2	1.5	9.7	3.31	W.	11.1
February	75.0	76.9	10.8	3.3	14.1	2.68	W.	11.3
March	76.0	75.7	11.0	3.9	14.9	3.41	W.	11.6
April	72.5	66.7	10.5	7.3	17.8	2.64	W.	10.4
May	62.0	62.3	12.5	9.2	21.7	3.31	W.	9.6
June	58.0	65.7	12.6	7.6	20.2	3.16	W.	8.3
July	48.0	66.7	14.7	9.2	23.9	3.52	W.	7.5
August	49.0	67.3	13.7	10.4	24.1	3.05	S.W.	6.9
September	64.0	69.6	12.3	8.8	21.1	2.36	S.W.	8.1
October	68.0	71.0	10.9	6.5	17.4	3.36	S.W.	8.9
November	70.0	75.5	9.3	2.9	12.2	2.91	W.	10.3
December	81.0	79.9	6.8	0.9	7.7	3.07	W.	10.8
Spring	97.0	68.2	34.0	20.4	54.4	9.36	W.	10.5
Summer	60.0	66.6	41.0	27.2	68 2	9.73	W.	7.6
Autumn	97.0	72.0	32.5	18.2	50.7	8.63	S.W.	9.1
Winter	82.0	79.0	25 8	5.7	31.5	9.06	W,	11.1
Year	110.0	71.4	133.3	71.5	204.8	36.78	W.	9.6

ROCHESTER. The accompanying chart, representing the climate of the city of Rochester, N. Y., and obtained from the Chief Signal Office, at Washington, is here introduced for convenience of reference. A detailed explanation of this and of other similar charts is given in the general article on Climate (vol. ii., pages 189 to 191), where also the reader will find suggestions as to the best method of using these charts.

Rochester lies in the so-called "Lake Region" of the United States, the city itself standing but seven miles distant from the southern shore of Lake Ontario. A reference has already been made to the winter cloudiness characterizing the climate of this district (see under Portland, Me., on page 782 of vol. v.). A comparison of columns K, L, M, N, and O in this Rochester chart, with the like columns in the chart for New York City, will demonstrate the decidedly greater cloudiness and relative humidity during the winter season at Rochester. The rainfall, which at New York is seen to be least in winter, is, at Rochester, least in autumn ; but throughout the year the quantity of the rainfall is more evenly distributed at the latter than at the former place, winter not being that *comparatively* rainless season at Rochester which it is at New York, although the winter rainfall of the two places is very nearly the same, and is, in fact, slightly greater at New York than at Rochester.

On the other hand, during the six months, April to September, inclusive, the relative humidity of the atmosphere is markedly lower at Rochester than at New York, and the cloudiness is nearly the same at the two places ; during the mid-summer months actually less at the former than at the latter. Thus, during the winter season Rochester is decidedly damper and more cloudy than New York ; during the summer season, and especially

the mid-summer season, New York is markedly damper and a trifle more cloudy than Rochester.

H. R.

ROCKBRIDGE ALUM SPRINGS. *Location and Post-office,* Rockbridge Alum Springs, Rockbridge County, Va.

ACCESS.—By the Chesapeake & Ohio Railway to Goshen, eight miles from the Springs.

ANALYSIS.—One pint contains:

SOLIDS.	No. 1. A. A. Hayes, M.D.	No. 2. A. A. Hayes, M.D.	No. 4. A. A. Hayes, M.D.
	Grains.	Grains.	Grains.
Chloride of sodium	0.053	0.126	0.055
Sulphate of potassa	.....	0.221	.....
Sulphate of magnesia	0.135	0.220	0.552
Sulphate of lime	0.180	0.408	0.413
Protoxide of iron	0.460	0.608	0.587
Alumina	1.846	2.238	3.011
Crenate of ammonia	0.175	0.088	0.153
Silicate of soda	0.318	.....	.....
Sulphuric acid (free)	2.347	1.903	0.689
Silicic acid (free)	.....	0.355	0.213
Organic matter	.....	.....	0.127
Total	5.514	6.167	5.800
GAS.	Cubic in.	Cubic in.	Cubic in.
Carbonic acid	0.7	1.9	1.1

THERAPEUTIC PROPERTIES.—There are here nine alum springs and one pure chalybeate, and their remedial value is attested by the decided cures effected in many instances. The alum waters are tonic and astringent. Their taste is astringent, and their temperature averages about 50° F. They cure catarrhal diseases of the alimentary and genito-urinary tract, and are famed for their beneficial influence upon chronic skin diseases, glandular enlargements, chronic ulcers, and, in fact, all scrofulous degenerations.

An experienced physician resides at the Springs, and directs the use of the waters.

The situation of these Springs is in the northwestern part of Virginia, in a glen at the base of North Mountain on the south and Mill Mountain on the north, amid the beautiful scenery of this section. The lawn, of about fifty acres, is partially surrounded by several fine hotels and cottages, affording accommodations for seven hundred guests. *Geo. B. Fowler.*

ROCKBRIDGE BATHS. *Location and Post-office,* Rockbridge Baths, Rockbridge County, Va.

ACCESS.—By the Baltimore & Ohio (Harper's Ferry & Valley Branch) Railroad to Timber Ridge Station, thence by stage to the baths, four and one-half miles.

THERAPEUTIC PROPERTIES.—These waters are principally employed as baths. They contain iron, lime, soda, magnesia, potassa, and iodine.

The springs are beautifully situated on the banks of the North James River, on the old stage road, passing through the celebrated Goshen Pass, from Goshen to Lexington, about ten miles from either place, amid some of the most picturesque scenery in Virginia. There are hotel accommodations at the baths. *G. B. F.*

ROCK CASTLE SPRINGS. *Location and Post-office,* Rock Castle Springs, Pulaski County, Ky.

ACCESS.—By the Louisville & Nashville Railroad (Knoxville & Bardstown Branch) to London, thence by stage to the Springs, eighteen miles.

THERAPEUTIC PROPERTIES.—This is one of the waters which should prove beneficial in disorders of digestion and allied complaints, simply from its purity; as the writer holds that the imbibition of pure water (in excess in disease) is one of the greatest aids in treatment.

ANALYSIS (Dr. Peters).—Composition in 1,000 parts:

	Grains.
Carbonate of iron	.0045
Carbonate of lime	.0438
Carbonate of magnesia	.0148
(Held in solution by carbonic acid.)	
Sulphate of lime	.0029
Sulphate of magnesia	.0036
Sulphate of soda	.0531
Chloride of sodium	.0026
Silica	.0128
Total	0.1381

The water contains 0.930 part per thousand, by weight, of free carbonic acid.

Rock Castle Springs is situated in Southeastern Kentucky, on the Rock Castle River, amid the wild and picturesque scenery of the Cumberland Mountains. The invigorating mountain air, the delightful atmosphere during the summer, the thermometer rarely rising above 85° F., and then for a few hours only, the nights being so cool as to require blankets during the entire season, and the grand scenery, have made this a favorable resort. The hotel, surrounded with wide verandas and a beautifully shaded lawn, has accommodations for two hundred and fifty guests. It is situated in a gorge at the base of a mountain four hundred feet high, and looks out on the river, on the opposite side of which there is a corresponding mountain height. Hunting, fishing, boating, excursions to the numerous points of interest in the neighborhood, bowling, etc., furnish ample amusement for the guests of the hotel. *George B. Fowler.*

ROCK ENON SPRINGS. *Location and Post-office,* Rock Enon Springs, Frederick County, Va.

ACCESS.—By Baltimore & Ohio Railroad (Harper's Ferry & Valley Branch) to Winchester, thence by stage to the Springs, sixteen miles and a half.

ANALYSIS (Professors Gale and Mew. Chalybeate Spring).—One gallon contains:

	Grains.
Carbonate of lime	5.13
Carbonate of soda	1.21
Carbonate of protoxide of iron	14.25
Carbonate of protoxide of manganese	1.05
Sulphate of magnesia	12.89
Sulphate of lime	3.56
Chloride of magnesium	1.12
Alumina	0.80
Silica	0.42
Total	40.43

THERAPEUTIC PROPERTIES.—This is a quiet retreat, and the use of the alkaline calcic waters has been of great service to many worn and exhausted constitutions. Accurate thermometric records show that the temperature during the summer never rises above 78° F.

Besides the Chalybeate there are two other mineral springs: "The Walnut," the water alkaline and its action diuretic and aperient, and "The Old Capper," efficacious in rheumatism and diseases of the skin. These three, together with five limestone springs, are close by the hotel. In the neighborhood are four sulphur springs of excellent quality.

Rock Enon Springs are situated in the northeastern part of Virginia, about forty miles west of Baltimore, on the western slope of the Great North Mountain, amid grand and picturesque scenery. The hotel possesses all the conveniences for the health, comfort, and amusement of its guests. It is supplied on every floor with pure water from the "Great Cold Spring" on Pinnacle Mountain, and the sanitary arrangements are complete. There are delightful walks and drives through the surrounding mountains and valleys.

The facilities for bathing are excellent, including hot and cold mineral and pure water baths, and a swimming pool seventy-five by twenty-five feet.

George B. Fowler.

ROCKY MOUNTAIN SPRINGS. *Location,* Boulder County, Col.; *Post-office,* Jamestown, Boulder County, Col.

ACCESS.—By Union Pacific Railway (Colorado Divis-

ion) from Denver to Boulder, thence by stage twelve miles to Springs.

ANALYSIS (C. T. Jackson).—One pint contains:

	Grains.
Carbonate of soda	0.474
Carbonate of magnesia	0.049
Carbonate of lime	5.414
Carbonate of iron	0.362
Chloride of sodium	0.620
Sulphate of soda	13.075
Iodide and bromide of sodium	0.162
Silicate of soda	0.500
Total	20.656

THERAPEUTIC PROPERTIES.—Mild alkaline, cathartic, and tonic waters.

These springs are situated in Northern Colorado, two miles from Jamestown, at an altitude of six thousand five hundred feet above sea-level. There are hotels and bathing facilities at the Springs. *George B. Fowler.*

ROETHELN. DEFINITION AND HISTORY.—Rötheln is an exanthematous disease of mild character, attended with a slight elevation of temperature, propagated by contagion, and bearing a close resemblance to measles and scarlatina. It is widely known in this country under the above appellation, and also, in common parlance, by the term "German Measles." The latter name being English, is generally used. Thus in its nomenclature Rötheln resembles the other exanthemata, which have each a technical and a common name. The Germans, however, use the names Rötheln and rubeola as synonyms; and this tends to confusion, since we signify by rubeola the different disease, true measles or morbilli. Various other names have been given to the disease by different writers, prominent among them being epidemic roseola, rubeola scarlatinosa, rubeola morbillosa, rubeola notha, and rubella. The last-mentioned name has been suggested as most appropriate, since it is a diminutive of rubeola, and thus the two words express the analogy existing between the two diseases, just as do the terms variola and varicella. For the reason, however, that Rötheln is more widely recognized, the writer retains it in this article.

Rötheln is, as far as definite knowledge is concerned, a new disease. As late as 1886 the "Index Medicus" gives it no separate place, and the articles on the subject are grouped under the heading of measles; yet the number of communications, treating of this affection, which have been written during the past ten years or so, will aggregate more than one hundred. Before that time, however, the disease had been from time to time spoken of, as far back as a century and over; though until the time of the present generation the greater number of observers did not consider it a distinct disease, but believed it to be a modification of measles, generally, and in some instances of scarlatina. Mention was made of epidemics in 1845 and 1853, and in 1873–74 the disease was carefully described, though under the name of epidemic roseola. In Germany attention was given to the subject many years before any English or American writings appeared. Now almost all physicians grant its individuality, and the arguments supporting this view will be presented hereafter.

AGE OF PATIENTS.—Rötheln is generally classed as one of the diseases of childhood; and, since there are no clearly proved instances of its second appearance in the same individual, it follows that those affected are usually young in years; the general rule being that any one of the contagious exanthemata is experienced but once in the lifetime of an individual. Still, it is much less prominently an affection of infants and children under five years of age than are the other eruptive fevers. Adults are frequently attacked, but the majority of those who suffer from this disease contract it some time before the age of puberty. In other words, the time of life when susceptibility is greatest is between the ages of two and fifteen years. Young infants do not seem to contract it, and it is believed that sucklings are not susceptible. As, however, it is a disease of less frequent occurrence than measles or scarlatina, and as it seems to be less actively contagious than those diseases, many growing children escape it; and these facts constitute a possible explanation of the circumstance that adults are not infrequently attacked during the prevalence of an epidemic.

The season of the year does not seem to exert any influence on its prevalence. Epidemics occur indifferently in hot and cold weather.

ETIOLOGY.—Rötheln is propagated by contagion, and by this means alone. The materies morbi is believed to be portable, but the cases in which the source can be traced point toward the necessity of close contact for the transmission of the disease from the sick to the well. In a single epidemic the total number of cases among those unprotected by having previously experienced the disease is found to be small in comparison with the other contagious exanthemata. Especially is this noticeable with reference to measles, which will attack, simultaneously or successively, all the susceptible children in a household almost with certainty; while we generally meet with a single, or perhaps two, cases of Rötheln, and the greater number of those exposed, in greater or less degree, escape. J. Lewis Smith, in one epidemic, saw forty-eight cases in twenty-one families—an average of a little more than two to each family. In an institution, such as an orphan asylum, the number of cases would be comparatively larger, since the exposure would be of necessity greater at first. Isolation, therefore, can be expected to accomplish more in the direction of prevention than it does with measles or scarlatina.

Rötheln is encountered almost exclusively in epidemics, and sporadic cases are very rare. This is probably more decidedly the case with Rötheln than it is with scarlatina, and possibly also with measles.

Considerable difficulty is experienced in tracing cases of Rötheln to their sources—largely, no doubt, because affected persons are frequently unconfined, owing to the general mildness of the disease, and the absence of alarm concerning it. Undoubtedly, however, if its origin could always be traced, an exposure to contagion would be discovered. In other words, it is practically certain that the disease does not originate *de novo;* nor is it produced by general causes, such as improper hygienic surroundings in the matter of poor ventilation, overcrowding, or insufficient or improper dietary conditions. On the contrary, it is not found to be a disease of greater proportionate prevalence in tenement-house districts, where the conditions referred to are in prominent existence. A large proportion of the cases are encountered in the families of the better classes, and, most of all, in institutions, such as orphan asylums.

We may reasonably conclude that Rötheln is less actively contagious than measles or scarlatina, since so many of those exposed escape. Under the same conditions of exposure the number of cases arising of either of those two diseases would probably considerably exceed those of Rötheln.

The age at which susceptibility is greatest has been mentioned, being considerably more advanced than that which obtains with the other exanthemata; but as yet there is little definite knowledge as to the stage of the disease itself in which propagation by contagion is most likely to occur. We can only say that the probability is in favor of contagiousness during the whole course of the disease—from the time when prodromal symptoms, if present, appear, until the eruption has entirely disappeared.

CLINICAL HISTORY.—*Stage of Incubation.*—Much attention has been given to the duration of the stage of incubation—the time elapsing between a traceable exposure and the onset of the disease. This is frequently made difficult of accurate investigation for the reason before mentioned, that isolation is not observed because of the mild character of the affection, and sometimes even confinement within doors is not enforced. The general experience is that this stage occupies from fourteen to twenty-one days; though in some epidemics the duration has been considerably less. Shuttleworth had the opportunity of ascertaining, in an asylum, that twenty-one days elapsed after the first case before the second oc-

curred, isolation being enforced, and two days later two fresh cases developed. Goodhart says that the incubation, in 23 out of 25 cases, was from fourteen to twenty-two days. Edwards gives six days as the shortest, and twenty-one days as the longest. Cheadle ascertained it to be eight days in one instance, nine in another, and (approximately) twelve days in five more. Griffith's experience was that in 26 cases the eruption appeared between the fifth and twelfth days after the first case. Therefore, it must be granted that considerable variation exists in the length of this stage, although we may consider that a period of fourteen days represents the average. The incubative stage of measles is much more constant—standing at thirteen and fourteen days.

Stage of Invasion.—In very many instances the eruption is the first thing calling attention to the existence of sickness. Since many of the patients are old enough to describe any subjective symptoms which may be present, it follows that the stage of invasion is frequently attended with little or no disturbance of general health. With children too young to describe their own sensations, the attention of parents is often attracted by no manifestation whatever—such as restlessness, or crying, or digestive disturbance—until the eruption becomes visible. It is, however, probable that there is always present a slight rise of temperature, not sufficient to cause discomfort; and close questioning might elicit an admission of a feeling of malaise. But, as stated, the breaking out of the rash is what causes uneasiness, and leads patients or parents to consult a physician for the purpose of ascertaining the nature of the sickness.

There are, on the other hand, cases in which there is more or less decided disturbance of health prior to the appearance of the eruption. Epidemics undoubtedly vary greatly in severity, as do individual cases in a single epidemic; and from the average of descriptions it would appear that the disease is more severe, as well as of more frequent occurrence, in Europe than in the United States. These more severe cases present certain indications of sickness, before the rash appears, which, taken in connection with known exposure, point toward Rötheln as the oncoming disease; but, in themselves, they have little value as regards the differential diagnosis, especially, from scarlatina and measles. The symptoms, when present, have special reference to the mucous membranes of the air-passages, and to the digestive system. They are: mild inflammation of the throat and tonsils, shown by swelling and redness on examination, and by pain and slight cough; a slight degree of coryza; conjunctival irritation, lachrymation, and a little tendency to œdematous swelling of the eyelids. Nausea and anorexia have been frequently observed, and in rare instances vomiting. Frontal headache in a few instances is the source of much discomfort. The digestive disturbances appear to have been prominent in some, and absent in other, epidemics. With these symptoms, and, it is not improbable, in their absence, there is a rise of temperature to 99° or 100° F. in mild, and as high as 103° in severe, cases. In addition to these indications there is one symptom highly characteristic of the fully developed disease, as will hereafter be seen, which has been observed in the prodromal stage. This is enlargement of the post-cervical lymphatic glands—not those at the angle of the jaw, as obtains in scarlatina and diphtheria, but those in the back of the neck. This enlargement should always be looked for, since it is the only feature of diagnostic value in the stage of invasion. Jaccoud found it, in five out of thirty-two cases, four or five days before the efflorescence. Associated with this, stiffness of the neck with pain on movement of the head, in slight degree, should be sought for.

Any throat inflammation present might easily be accounted for in expecting scarlatina to develop; and coryza, cough, and conjunctival irritation belong to the clinical history of measles. Rise of temperature also, of course, accompanies the onset of both these diseases; and consequently, excepting only the glandular enlargement, as far as these general symptoms are concerned, it is only in their lesser degree of severity that they are characteristic of Rötheln rather than of the other two affections.

These indications, when present, precede the eruption by a period, in the great majority of cases, of less than twenty-four hours; although in some instances malaise is present for three or four days before this stage is ended. Cheadle, in describing a severe epidemic, observed that the prodromal symptoms persisted longer in severe than in mild cases. Edwards gives the average duration as three days.

It is therefore observable that the stage of invasion, when present, is subject to considerable variation—both as to length and severity—and is, in fine, a much more uncertain quantity than is that of scarlatina or measles.

Stage of Eruption.—The prominent feature of the disease is the eruption, often, as before stated, being the only phenomenon perceptible, and generally being by far the most prominent manifestation of a condition of sickness. Very great differences, in different epidemics and in individual cases, are to be found; and, considering the eruption alone, a diagnosis might well be difficult, if not impossible. As the symptoms other than the eruption, such as those found in the prodromal stage, present considerable variation, and as this fact holds with the eruption itself, we may conclude that the disease, as a whole, is far less *stable* than scarlatina and measles. These are more than variations of degree—they affect the essential characters of the symptoms and of the eruption.

Scarlatina, for instance, may be very mild or very severe as regards the throat inflammation and fever; and its eruption may be difficult of detection, or as marked as a pronounced rash of erysipelas; but these are differences of degree, and the sore throat and eruption are uniformly present, and are *sui generis.* The same rule holds with measles. The essentials of the disease—the catarrh of the respiratory tract, and the characteristic eruption—may, one or both, be very mild or very severe; but they must both be present in any case where the diagnosis is undoubted. Rötheln, on the other hand, may consist, from beginning to end, of the eruption only, or may present some of quite a variety of symptoms affecting the mucous membranes of the air-passages or of the digestive apparatus.

Regarding the eruption itself, its characteristic points are as follows: Its color is generally a pale rose, less distinctly rose-hued than that of measles. It is very frequently brownish, brownish-red, and sometimes quite distinctly brown, with no tinge of rose or pink to be detected, and giving the general effect of duskiness.

As to location, no part of the surface is entirely exempt. The palms of the hands, the soles of the feet, and the scalp have been observed to present it; although usually it is not to be found in those regions. As a general rule, the face, trunk, arms, and legs break out successively before the final disappearance of the rash; although cases are often described in which the affected area is much less extensive.

Either the face or the upper part of the body may be first affected, and the spread of the eruption is rapid—one day or less sufficing for its appearance on the remoter parts after its initial appearance. The maximum of intensity is very quickly attained. Beginning on the face, for example, in very faintly marked spots, after a period of a few hours, and certainly within one day, it will be at its height, and the spots will be plainly visible. Then a fading process sets in, gradually progressing, accompanied with, or followed by, some desquamation, and continuing for about two days; so that, in any selected locality, from the first appearance to the final disappearance, an average period of three days is occupied. This, however, is not a definitely fixed time; sometimes it embraces but two days, and at other times it is protracted to six or seven.

The duration of the eruption as a whole, without reference to any special part of the surface, is consequently a little longer than that of its presence in a given locality—by the time occupied in the spreading from the region first to that last attacked. As this generally requires one

day, or somewhat less, the eruptive stage of the disease can be expected to continue about three days on the average, though subject to the variation spoken of, having as extremes two and seven days. It will be observed, from the rapidity of development in a selected locality as compared with the rapidity of the spreading to other regions, that different parts will present the eruption in greatly varying conditions; and that at no given time will it be at its maximum uniformly over the entire surface of the body. In other words, it may even reach its height in one part before appearing in another. This is a point of value in diagnosis, and of contrast to scarlatina and measles, in both of which there is generally a stationary period as regards the spread and intensity of the eruption after the maximum has been attained.

The eruption is papular. If the hand is passed gently over it, a sense of roughness, at least, is perceptible, showing a certain degree of elevation above the surrounding skin. From this very slight condition of elevation differences are to be found up to a state in which the elevation is distinctly and at once visible—as much so as in a fully developed rash of measles. But, in some degree, elevation of the spots is always present, and therefore it is a mistake to describe the eruption as macular.

The size of the papules is one of the points in which there is considerable variation. In general they are smaller than the papules of measles, varying from the diameter of a pin's head to that of a pea. In a certain proportion of cases the spots are so small as to constitute mere punctation, and the skin presents the appearance of being covered with innumerable fine dots. They are of irregular shape, but with a more decided tendency to assume the circular form than those of measles. In a given case there is generally some uniformity in the matter of size—either the papules are for the most part of the larger size, or they are nearly all small. Still greater differences of size have been described, however, papules of one-third of an inch in diameter having not infrequently been encountered.

Generally the skin between the papules presents a perfectly healthy appearance, although careful investigation will occasionally reveal the existence of minute fine lines or processes connecting adjoining papules. A general erythematous redness of the skin has also been noticed. Confluence of the papules is very rare, though not uniformly absent.

Vesicles have been observed, but this has clearly been a coincidence, and not at all a part of the ordinary course of the eruption. They are probably found quite as often with measles, and in either case must be regarded as anomalous. The eruption has been observed to suddenly disappear, and after a short time to reappear; and unusual warmth, as from heavy clothing, renders it more distinctly visible. A certain amount of itching is often present, though not severe, and the heat and burning, which are a source of discomfort in scarlatina and measles, are not at all pronounced in Rötheln.

To sum up the characteristics of the eruption, we may make a division of the cases into two classes, which correspond with the descriptions formerly given of rubeoloid Rötheln on the one hand, and scarlatinoid on the other. In each variety the resemblance to the other disease, as far as the eruption is concerned, may be very close—often sufficiently so to render the diagnosis extremely uncertain, if the other points of history and symptomatology be not carefully considered.

In the first class of cases, comprising the greater number, the papules are of larger size, perhaps abundant enough to be considered confluent, of somewhat irregular shape, pale rose color, and raised considerably above the skin. It will be seen that this state of affairs can obtain with measles quite as well as with Rötheln.

In the second class the papules are smaller, more circular in shape, less elevated above the skin, of darker hue, much more numerous, and sometimes very closely aggregated, so as to give the punctated appearance alluded to. If this be the appearance, there may easily be nothing in the eruption by which to discriminate it from a scarlatinal rash at the onset or during the first day of the disease. A fully developed rash of scarlatina is continuous, leaving no skin normal in appearance between the eruptive spots; and in Rötheln the papules are distinctly separated from each other.

Taking, therefore, an extreme case of either variety, it will be found that other points in symptomatology and history are requisite, and possibly a delay for one or two days may be necessary, in order definitely to eliminate doubt in the diagnosis.

Desquamation.—Desquamation is the mode, or perhaps a better term would be the accompaniment, of the termination of the eruption, beginning on the second or third day. It is furfuraceous in character, never occurring in large scales or pieces of skin as in scarlatina. It is fine, and in this resembles more the desquamation of measles. It is much less decided than in scarlatina, and is often so slight in amount as to be perceived only on very careful inspection, and frequently passes unnoticed by either the patient or the physician. Many writers on the subject do not make mention of the process, and frequently the statement is made that it is not a part of the clinical history of the disease. The writer cannot contradict this, though holding the view that it is present in some degree in all cases. As fading of the color of the eruption very quickly sets in, and is progressive until its final disappearance, the desquamation is the accompaniment of this.

The desquamation is not to be found affecting at one time the entire surface which has presented the eruption. It follows the appearance of the rash, and, consequently, is visible on one part of the surface before it is on another. Furthermore, it does not take place over the entire affected surface—much of the eruption fades away without desquamation, and the latter is to be searched for about the trunk, legs, and arms especially. The face and extremities usually escape. In this there is another point of resemblance to measles.

Following the customary division of the eruptive fevers into stages, we may consider the stage of desquamation, fading, or decline, to occupy the time from the second day of the eruption to the end of the disease. But it must be borne in mind that the line of division between these two stages, *i.e.*, of eruption and of desquamation, is much less distinctly marked than in scarlatina or measles.

Occasionally a faint staining or pigmentation has remained for several days after the disappearance of the rash proper.

Symptoms other than the Eruption.—These have been in part considered under the head of premonitory symptoms, or those presenting themselves in the stage of invasion, and are, in great part, simple continuations of them. They are found, like those of scarlatina and measles, to have special reference to the mucous membranes of the nose, throat, and conjunctiva, together with more or less disturbance of the digestive functions. The inflammatory condition of the throat and tonsils, which is the most frequent of these symptoms, varies greatly in degree, and, beginning in the stage of invasion, persists up to the time when the rash has reached its height, and then subsides with the disappearance of the rash. Slight cough sometimes persists a few days longer. The conjunctival irritation and the œdematous swelling of the eyelids are not often pronounced, and follow much the same course as the throat-symptoms.

The nausea, which presents itself often enough to call for special mention, is generally noticeable only until the rash has developed.

The tongue is commonly coated, but does not at all present the appearance of the strawberry tongue of scarlatina. All these symptoms, when present at all, are of decidedly milder character than they are in scarlatina and measles.

The temperature range has been referred to as being liable to differences in epidemics and in individual cases. As a general rule, the rise is much less than that of the two other diseases. An elevation of one to two degrees—to 99½° or 100½° F.—is what we may look for, persisting about three days, and in the given case not presenting

the fluctuations characteristic of measles, but remaining at the same level until its final subsidence.

The pulse and respirations are accelerated in proportion to the rise of temperature.

In general a severe case presents a greater variety of these symptoms, as well as a greater severity, and a mild case, absence, or nearly such, of them.

The single phenomenon, over and above the eruption, which is characteristic, and one might almost say pathognomonic, of Rötheln, is the enlargement of the post-cervical and sub-occipital lymphatic glands. Probably in no case is it found wanting. This occurs at the onset of the disease, and therefore, as stated, may not infrequently be discovered before the appearance of the eruption. The number of glands affected varies from one or two up to seven or eight. Search should be made for them from the occiput down to the level of the shoulders, and toward the middle of the neck rather than at the sides or near the angle of the jaw. In scarlatina, diphtheria, and other throat affections, the glands which present enlargement are those at the angle of, as well as beneath, the lower jaw. In such instances the swelling seems to be proportionate to the severity of the throat inflammation, and to be associated with it, as in adenitis in the neighborhood of inflammation elsewhere in the body. But the adenitis of Rötheln cannot be so explained, as it is found equally in the cases with considerable sore-throat, and in those with none. Therefore it should be regarded as a distinct phenomenon of the disease, and not as an accessory.

Associated with the enlargement is stiffness of the neck, and pain on moving the head, in some degree, though never very severe. The enlargement itself varies, the glands being of about the size of a split pea or bean; suppuration does not occur, and the swelling and pain subside with the disappearance of the eruption. Occasionally a single gland will remain perceptibly enlarged, though painless, for an indefinite length of time.

Valuable as this point is, there are yet sources of error, and glandular enlargement from other causes must be excluded.

The condition which we recognize as struma, indicating the general condition of ill-health due to bad hygienic surroundings and malnutrition, has, as a prominent feature, general glandular enlargement, perceptible in the groins, axillæ, etc., as well as in the neck; and syphilis may present the same condition. Accordingly, search should be made in those other localities before assigning a cervical adenitis to an oncoming, or present, attack of Rötheln. Enlargement of the glands at the angle of the jaw is to be attributed to other causes. Children with eczema capitis have, almost always, large lymphatic glands in the neck.

During an epidemic of measles in 1886, the writer made investigation with special reference to this point, and found that in 24 out of 29 cases an enlargement of glands exactly similar to that of Rötheln was present, and constituted a prominent feature of the cases. This was evidently a peculiarity of that epidemic, as the writer has neither before nor since found it to be the case, except in isolated instances. Griffith states that he has not infrequently found it. Care was taken to render the diagnosis of measles certain, and mention is made of this point here to show that the adenitis characteristic of Rötheln is not absolutely pathognomonic, and will not in itself suffice for differential diagnosis from measles.

Non-identity with Measles and Scarlatina.—The writer has, of necessity, made frequent mention of Rötheln as contrasted with scarlatina and measles, and the reasons for considering it to be an independent disease must now be considered. There are still some who consider it a hybrid, consisting of elements drawn from both those diseases, and being intermediate in character between them. This position is scarcely tenable, and is not supported by clinical facts; since the greater number of cases, though having points in common with both, present, each one, strong points of resemblance to one or the other of the two affections, and not to both at the same time. That is, any single case is either decidedly scarlatinoid or decidedly rubeoloid; and the differential diagnosis lies between two and not three diseases. Furthermore, hybrids are not at all common, and analogy is opposed to this view. Generally, what is called a hybrid can be resolved into its elements, and may be pronounced a conjunction of two or more disease-conditions. Undoubtedly scarlatina and measles may be found coexisting in the same individual, or following each other so closely as to overlap, the inmates of a household being exposed to and contracting both diseases at the same time, or in rapid succession. These cases, however, present the phenomena of both diseases in such a manner and degree as to exclude uncertainty in the diagnosis, and they bear no closer resemblance to Rötheln than any single well-pronounced case of either disease.

The question of its identity with one or the other of these diseases calls for more careful consideration.

There are but few who believe Rötheln to be identical with scarlatina, but many consider it of the same nature as measles. In a scarlatinoid case the principal points in common are: the short period of invasion, the existence of some sore-throat, and the fine punctate appearance of the rash at first. Rötheln is liable to be confounded only with a very mild case of scarlatina; for the vomiting, high fever, pronounced sore-throat, and characteristic tongue of average scarlatina are not encountered in the former disease. The points of difference are most prominent in the longer duration of the eruption in scarlatina, its greater uniformity, its macular character, the nature of the desquamation, and the presence of sequelæ which do not occur in Rötheln. In addition to which the adenitis of Rötheln is not to be found in the other disease.

As to measles, the similarity also exists in a certain proportion of cases of mild character. The symptoms which may be common to both are the rose color and papular character of the rash, the shorter duration of the period of eruption, the fine desquamation, and possibly the adenitis. The main point of difference is the presence, in measles, of two or three days of fever, with catarrhal inflammation of the respiratory mucous membranes, uniformly preceding the eruption. The sequelæ of measles, also, are not to be expected in Rötheln.

As stated, these resemblances are encountered only in extreme cases. Average cases of each disease have special characteristics sufficient to clear away doubt; and the differences just enumerated go far toward proving non-identity in either direction. But the strongest reason for believing in the individual nature of Rötheln—constituting, indeed, a conclusive proof—is that no mutual protection is afforded. That both scarlatina and measles are, if the expression be allowed, auto-prophylactic, has been proven by thousands of observations. Second attacks of scarlatina are so rare as to be curiosities in the history of medicine; and with measles, although the rule is not so free from exceptions, yet a second attack is a very infrequent occurrence. This rule applies to Rötheln. As yet there are few, if any, authentic records of second attacks. But when the question of mutual protection, which would be a *sine qua non* to the supposition of identity, is considered, the most conclusive evidence of its absence is presented.

Of J. Lewis Smith's 48 cases, 19 had had measles, and 1 contracted the disease subsequently. Of Shuttleworth's 30 cases, more than half had had measles, and 4 scarlatina. In one case the patient had measles five months, and scarlatina one month, before. In 13 of the cases, where subsequent observation was possible, 7 contracted measles, and 6 scarlatina, after the lapse of a few years. Goodhart observed that 39 out of 63 cases had had measles.

Instances might be multiplied to a very large number, but it is unnecessary; for the non-existence of mutual protection is too well established to admit of doubt. There is, however, another aspect of this question, or, rather, another explanation of the facts, which has been presented with considerable appearance of probability. It is that Rötheln is simply the modification of measles presented in second attacks, bearing the same relative

position that varioloid does to small-pox. There are two reasons for regarding this position as untenable. The first is, that pronounced attacks of true measles have, in a large number of instances, followed, and not preceded, Rötheln, and these cases have presented no modification in kind or severity of the symptoms which go to make up the clinical history of measles. This applies with equal force to scarlatina. The second reason is, that in the individuals who have been the subjects of second attacks of measles, the symptoms have been as uniform and pronounced as in the first.

On the contrary, a much closer analogy can be traced between small-pox and varicella on the one hand, and measles and Rötheln on the other. The ratio is much the same in regard to corresponding severity, and in similarity of appearance of the eruption.

The final separation, in the minds of medical men, of the former pair from each other, was beset by the same uncertainties as that of the latter.

Another fact of significance is that Rötheln occurs in epidemics, when neither scarlatina nor measles is prevailing; and, in the same epidemic, most of the cases will be rubeoloid, and a smaller number scarlatinoid.

Text-book descriptions of measles commonly refer to a variety of the disease under the designation of "rubeola sine catarrho," this name indicating a condition in which there is fever, with an eruption similar to that of ordinary measles, and at the same time absence of the inflammation of the respiratory apparatus. Perhaps it is fair to consider these as cases of Rötheln; and a significant observation made by Watson, in his "Practice of Medicine," gives support to this view. He says: "It is observed that rubeola sine catarrho confers no protection against recurrence—is commonly succeeded by an attack of measles in its true form." Meigs and Pepper make the same observation as to their experience.

To summarize, the points demonstrating the non-identity of Rötheln with measles or scarlatina are:

1. The difference in clinical history.
2. Absence of mutual protection.
3. Absence of modification in second attacks of those two diseases.
4. Occurrence of epidemics while the other two are not prevailing.
5. In any epidemic, resemblance of some of the cases to one, and of some to the other, of the two diseases.

A further differentiation of the two varieties into two distinct diseases is possible; but it would be a refinement almost beyond our present powers of observation.

Diagnosis.—The diagnosis is principally made by process of exclusion, because, at the outset, the presence of scarlatina or measles is generally suspected. From scarlatina at the outset, or in the first day or two of sickness, in certain mild cases, the points of difference are: In Rötheln, the absence of, or presence in a milder degree, of sore-throat; the absence of the strawberry tongue, and the existence of a whitish coating if any change be present; the absence of continuity of the eruption; and the presence of post-cervical adenitis, the glands at the angle of the jaw being unaffected. After the lapse of two or three days the course of the eruption in Rötheln is to reach its maximum and begin to disappear quickly, and the desquamation, when perceptible, is fine, and not in flakes or patches of some size.

Pronounced cases of scarlatina do not resemble Rötheln sufficiently to render the diagnosis uncertain.

From measles the discrimination is to be based mainly on the absence of the stage of fever with catarrh preceding the eruption, or its very mild character and shorter duration. The cervical adenitis has much weight, though it is not absolutely conclusive. Though the rash may very closely resemble that of measles, yet the papules are less elevated, smaller, less aggregated, less decidedly rose-colored, and run their course more quickly —desquamation setting in two or three days before it would be likely to occur in measles.

Subjoined is a comparative table of these three diseases in their different stages, giving also the average duration of each stage.

Rötheln.	Scarlatina.	Measles.
	Stage I.—Incubation.	
Duration, six to twenty-one days.	Two to fourteen days.	Twelve to fifteen days.
Inconstant.	.	Constant.
	Stage II.—Invasion.	
One day or less.	Less than one day.	Two to four days.
Often absent.	Never absent.	Never absent.
Malaise, slight.	Vomiting.	
Sore-throat and lachrymation.	Decided sore-throat.	Drowsiness, cough, coryza, conjunctivitis, photophobia.
Cervical adenitis.		
Temperature, 99°–100°.	Temperature, 103°+.	Temperature, 102°+.
	Stage III.—Eruption.	
Three days.	Six to eight days.	Four to five days.
Begins on face or chest.	Begins on chest.	Begins on face.
Papular, slightly.	Macular.	Papular, decidedly.
Pale rose, or darker and brownish.	Deep-red scarlet.	Rose.
Not continuous.	Continuous.	Not continuous.
Ceases spreading in one or two days.	Ceases spreading in three or four days.	Ceases spreading in two or three days.
No stationary period.	Stationary period of two to three days.	Stationary period of two to three days.
Burning or itching, slight.	Burning, often great.	Burning and itching, decided.
	Stage IV.—Desquamation.	
Very slight and fine.	In scales of quite large size.	Furfuraceous, and often not pronounced.
Overlaps stage of eruption.	Preceded by stationary period.	Preceded by stationary period.
Lasts two or three days.	Lasts ten days, and sometimes longer.	Lasts about four days.
		Leaves dull colored stains.
	Complications.	
	Acute form of Bright's disease.	Bronchitis.
None characteristic.	Rheumatism.	Pneumonia.
	Otorrhœa, and necrosis of temporal bone.	Tuberculosis.
		Inflammation of the intestines.

In addition to these other exanthemata, certain simple skin diseases must be considered in the diagnosis. Sometimes the eruption of miliaria papulosa (prickly heat) resembles that of Rötheln; but it occurs in well-defined patches of several inches in diameter, is associated with unusual sweating, and lasts many days longer. Also, there are no febrile and constitutional symptoms accompanying miliaria, and the itching is usually great.

The most careful investigation possible into the origin or sources of contagion should be made; and in cases of doubt a positive diagnosis should be withheld for one or two days. It may be advisable to explain the uncertainties, and to adopt the precautions as to isolation, etc., necessary in scarlatina.

Complications.—Complications or sequelæ characteristic of the disease do not exist. A condition of transient albuminuria is spoken of, but it is not indicative of renal disease. After the rash disappears we may expect to find the usual condition of health present. The prognosis is therefore good.

Treatment.—Because of the mildness of the disease there is generally nothing called for in the matter of medication—simple restriction of diet and avoidance of exposure during the continuance of the elevated temperature being all that is necessary. Practically the interest and importance attaching to Rötheln lie in recognizing it as a separate disease, and in the exclusion of the more serious affections, scarlatina and measles.

Bibliography.—Besides the treatises of Meigs and Pepper, J. Lewis Smith, Vogel, Day, Goodhart, Eustace Smith, and Ellis, on "Diseases of Children;" those of Bristowe, Bartholow, Loomis, Aitkin, and Flint, on the "Practice of Medicine;" and Da Costa's work on "Medical Diagnosis," the following articles may be mentioned: Hardaway, in "Pepper's System of Medicine;" Hartshorne, in "Reynolds's System of Medicine;" Thomas, in "Ziemssen's Cyclopædia;" Cheadle, Shuttleworth, and Squire, in the "Trans. Internat. Med. Cong.," 1881; Griffith, in the N. Y. *Medical Record*, July 2 and 9, 1887; Edwards, in the *Am. Jour. Med. Sci.*, 1884; Jones, *Boston Med. Journ.*, 1881; Sholl, *Med. and Surg. Reporter*, 1882; T. D. Swift, *N. Y. Medical Journal*, November 27, 1886; Harrison, *Am. Journ. Obstet.*, 1885; Duck-

worth, Erskine, and Gowers, in London *Lancet*, 1880; Dukes, ibid., 1881; Yonge-Smith, ibid., 1883 and 1886; Strover and Jaccoud, ibid., 1886; Shuttleworth, Brown, Burnie, Davis, Rooke, and Wilson, in *Brit. Med. Journal*, 1880; Byers and Sadell, ibid., 1881; Lawrence, ibid., 1882; Shackelton and Cullingworth, ibid., 1883; McLeod, ibid., 1885; and Ryle, ibid., 1886.

Thomas D. Swift.

ROHITSCH-SAUERBRUNN, an Austrian spa, lies in a well-protected valley, near Poltschach, Steiermark, at an elevation of about eight hundred feet above sea-level. It contains seven medicinal springs, the waters of two of which only, the Moritzquelle and the Tempelbrunnen, are used internally. The following is the analysis of the Tempelbrunnen. Each litre contains:

	Grammes.
Sodium chloride	0.094
Sodium sulphate	2.024
Sodium bicarbonate	1.075
Calcium bicarbonate	2.226
Magnesium bicarbonate	1.970
Ferrous bicarbonate	0.011
Organic matters, etc	0.025
Total	7.425

There is a variable amount of free carbonic acid gas.

The waters of Rohitsch are employed in the treatment of chronic catarrhal affections of the respiratory and digestive systems, corpulence, malarial cachexia, and passive congestions of the abdominal viscera.

The climate is mild. The season extends from the first of May to the middle of September. *T. L. S.*

ROSEMARY (*Rosmarinus*, U. S. Ph.; *Romarin*, Codex Med.), *Rosmarinus officinalis* Linn.; Order, *Labiatæ.* This is a fragrant, evergreen shrub, from two to four feet high, with numerous grayish-brown branches. Twigs square, gray, covered with stellate hairs. Leaves from one-half to one inch or more long, thick, leathery, linear, blunt, with revolute margins, entire, dark green and shining above, covered with white stellate hairs beneath. Flowers axillary, in pairs, half an inch or so long, pale lilac; calyx, two-lipped; corolla also labiate, the upper lip bifid, the lower of three diverging lobes, the middle one of which is much the largest and deeply concave. Stamens four, the two upper rudimentary. Style long, ovary of four, nearly separate, rounded carpels. Fruit, four subglobose achenes. Rosemary is a native of the Mediterranean region (Southern Europe, Asia Minor, Northern Africa, etc.). It is also an old and widely cultivated garden-plant. The pungently aromatic leaves are officinal.

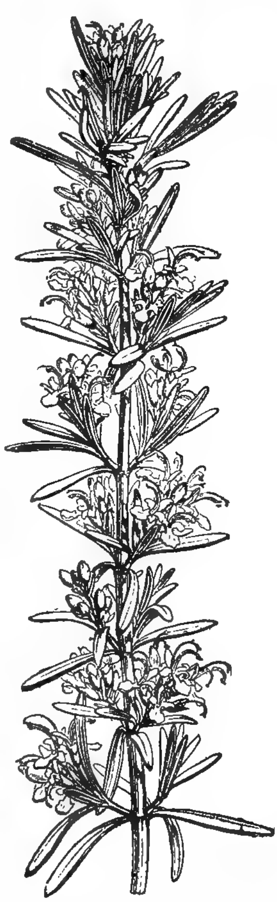

Fig. 3347.—Rosmarinus Officinalis; flowering branch. (Baillon.)

The principal constituent of Rosemary is the *essential oil*, a composite substance consisting of two or more hydrocarbons and a stearoptene. It is "a colorless or yellowish liquid, having the characteristic pungent odor of Rosemary, a warm, somewhat camphoraceous taste, and a neutral or faintly acid reaction. Sp. gr. about 0.900. It is readily soluble in alcohol."

This plant has the general aromatic properties of the rest of the order, but from its less agreeable taste is not so often given internally as the mints proper. Its pleasant odor, on the other hand, makes it, like Thyme, Patchouly, etc., a pleasant addition to liniments and cosmetics. Rosemary leaves are one of the ingredients of the obsolete Aromatic Wine (*Vinum Aromaticum*, U. S. Ph.), of which they comprise one per cent. The oil constitutes one per cent. of Soap Liniment, two per mille of Compound Tincture of Lavender, and eight of the officinal Cologne Water.

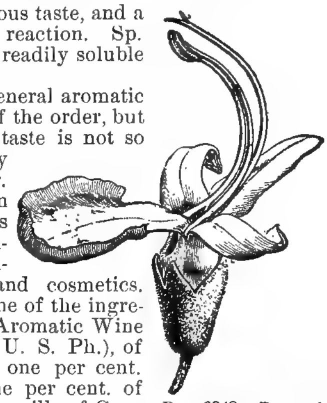

Fig. 3348.—Rosmarinus Officinalis; flower. (Baillon.)

Allied Plants, etc.—See Peppermint.

W. P. Bolles.

ROSES. These beautiful flowers contribute far more to man's pleasure than to his necessities. The genus *Rosa* gives the name to the great order *Rosaceæ*, and is the type of one of its divisions. It contains numerous not well-defined species of upright, climbing, or sprawling, mostly prickly, shrubs, with odd pinnate, conspicuously stipulate leaves, and terminal or clustered, showy, sweet-scented flowers. The floral envelopes and stamens are borne up on the thickened rim of a deep, vase-like, hollow receptacle, whose inner surface is covered with the numerous one-ovuled pistils. This receptacle, with its enclosed ovaries and crowned by the persistent calyx, ripens to a sourish-sweet fruit (rose hips). Calyx mostly five-parted; petals in single varieties mostly five: stamens very numerous, pistils moderately so. Some of the more familiar species follow:

R. lutea Mill. (*R. Eglanteria*), Eglantine Rose; Yellow Rose, with solitary large, handsome, yellow flowers. Southern Europe.

R. cinnamomea Linn., Cinnamon Rose.

R. canina Linn., the Dog Rose, or common Wild Rose, has stiff, compressed, recurved prickles serrate or lobed, reflexed sepals, a rounded, ovoid, scarlet, shining fruit, and clustered pink flowers. A common denizen of by-ways and hedges in most parts of Europe. The "Hips" (*Cynorrhodon*, Codex Med.), when fully ripe, and, preferably, touched by the frost, make a rather poor but edible kind of fruit, which in Southern Europe is made into jams and sweet sauces. They contain *citric* and *malic acids* and their salts, *sugar*, and a large amount of *gum*. A confection of rose hips is still a little used abroad as a vehicle. The galls produced upon this rose were also formerly used. Its name is said to have been derived from reputed value in dog-bites.

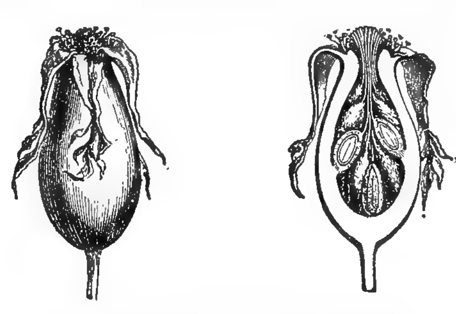

Fig. 3349.—Dog Rose Hips; about natural size. (Baillon.)

R. rubiginosa Linn., and *R. micrantha* Smith, are the

large and small-flowered sweetbriers easily recognized by their very fragrant leaves and stems.

R. Gallica Linn., the Provins or Red Rose has creeping rhizomes which send up a colony of rather short (two to four feet) stems. These are armed with numerous short, straight, weak prickles, and a few longer ones, and are covered with bristly hairs. The leaves are also somewhat hairy beneath, and blue-green in color. The flowers grow singly or in twos. They have a glandular, hairy receptacle and calyx, dark-red petals, and a nearly globular fruit. A native of Central Europe, but long under cultivation, for medicine as well as ornament. The petals, pulled or cut away, just before expanding, and dried, are officinal (*Rosa Gallica*, U. S. Ph.; *Rosæ Gallicæ Petala*, Br. Ph.; *Rose rouge ou Rose de Provins*, Codex Med.). When carefully dried they have a fine purple-red color and fine fragrance. They usually remain in the same cone-shaped bunches in which they were plucked, and unless cut away rather high, show whitish or yellowish claws. They contain a minute quantity of *essential oil*, some *fat*, *quercitrin*, a little *gallic* and *tannic* acids, and a beautiful *coloring matter*. As may be inferred, they have no active properties, and are only used for their color or as a vehicle.

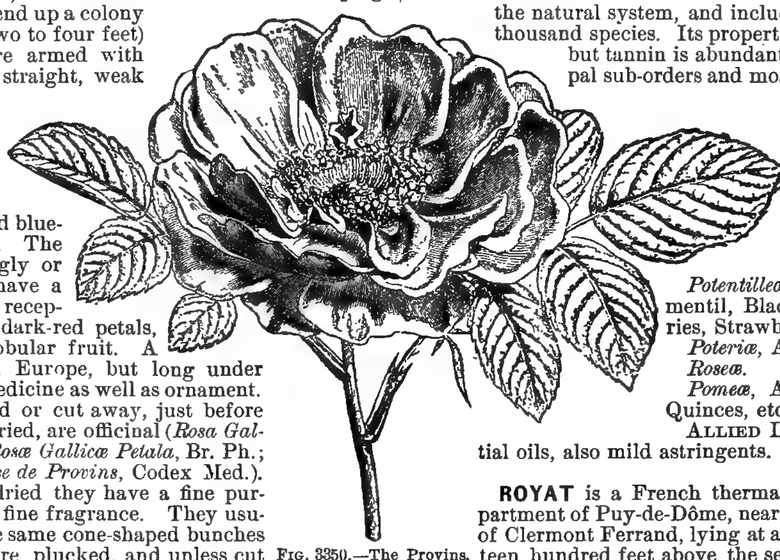

FIG. 3350.—The Provins, or Red Rose, in full bloom. (Baillon.)

The Pharmacopœia has the following preparations: Confection (*Confectio Rosæ*)—

Red Rose	8 parts.
Sugar	64 "
Clarified Honey	12 "
Rose Water	16 "

rubbed and beaten to a smooth mass, suitable for pills; Fluid Extract (*Extractum Rosæ Fluidum*); Honey (*Mel Rosæ*), strength, $\frac{8}{100}$; Syrup (*Syrupus Rosæ*), strength, $\frac{1}{10}$. It is also employed in making the Pills of Aloes and Mastich. Red Rose petals are collected in England, France, and Belgium.

Rosa centifolia Linn., possibly a variety of the above, is the parent stock of numerous fragrant, very full-flowered varieties. It has large, hooked prickles, and drooping, generally double, pale-colored flowers. A native of the Orient, but cultivated from time immemorial. The Moss Rose is one of its almost innumerable forms. Pale, Hundred-leaved, or Cabbage Rose petals (*Rosa Centifolia*, U. S. Ph.; *Rosæ Centifoliæ Petala*, Br. Ph.; *Rose à cent feuilles*, Codex Med.; *Flores Rosæ*, Ph. G.), collected and carefully dried after the expansion of the flowers, are, more or less, heart-shaped or abovate, have a pink color, a sweetish, slightly astringent taste, and a delicious rose-like odor. When fresh they are a source of Rose Water (*Aqua Rosæ*, U. S. Ph.); when dry, used for various pleasant but unimportant purposes, but mostly as a perfume.

R. damascena Mill (*Rose de Damas ou des quatre saisons*, Codex Med.). The Damask Rose, another Eastern species, has large, hooked prickles and fine sweet flowers. It is one of the sources, at least, of the Oil of Rose (*Oleum Rosæ*, U. S. Ph., Ph. G., etc.). The only important constituent of this rose and some others is the minute quantity of oil that they contain. This is separated by distillation and in great demand for perfumery. It contains a hydrocarbon of little odor, and several fragrant stearoptenes that cause the whole oil to congeal at a moderately low temperature (50° F.).

Besides the above, the Tea Rose, *R. Indica*, and numerous others are cultivated for ornament, and several American ones have begun to be. All the roses become double in the garden; most of them hybridize readily.

ALLIED PLANTS.—The order is one of the largest in the natural system, and includes more than one thousand species. Its properties are very diverse, but tannin is abundant in it. The principal sub-orders and most useful species are as follows:

Pruneæ, Almonds, Peaches, Plums, etc. (see ALMONDS).

Spiræeæ, Spiræas, etc.; Hardhock, Gillenia, etc.

Potentilleæ, Potentillas, Tormentil, Blackberries, Raspberries, Strawberries.

Poteriæ, Agrimony, Koosso.

Roseæ.

Pomeæ, Apples, Pears, Quinces, etc.

ALLIED DRUGS.—The essential oils, also mild astringents. *W. P. Bolles.*

ROYAT is a French thermal station in the department of Puy-de-Dôme, near the railroad station of Clermont Ferrand, lying at an elevation of fourteen hundred feet above the sea. There are five springs.

The following are the analyses of the two which are the richest in saline constituents, given in grammes per litre.

	Source Principale.	Source Saint-Mart.
Potassium bicarbonate	0.425	0.365
Calcium bicarbonate	1.000	0.953
Magnesium bicarbonate	0.677	0.611
Ferrous bicarbonate	0.040	0.042
Manganous bicarbonate	trace	trace
Sodium bicarbonate	1.349	0.421
Sodium sulphate	0.183	0.163
Sodium phosphate	0.018	0.007
Sodium arseniate	trace	trace
Sodium chloride	1.728	1.682
Silicic acid	0.156	0.102
Total	5.586	4.346

There is a considerable amount of free carbonic acid gas. The temperature of the different springs ranges from 82° to 95° F.

The waters of Royat are taken internally, and also employed in baths of various kinds. The whey- and grape-cures are also used to some extent. The diseases in the treatment of which the Royat waters are recommended are chlorosis and anæmia, debility following convalescence from acute diseases, vesical catarrh, muscular rheumatism, and certain forms of eczema. A course of treatment lasts from two to four weeks. The season extends from June to the middle of September.

T. L. S.

RUBINAT-CONDAL. This is the name of a natural mineral water recently introduced into this country, which, it is claimed, is one of the best of the natural saline aperients. The following is given as its composition, according to an analysis of Dr. Canudas y Salada. One litre contains:

	Grammes.
Magnesium sulphate	3.172
Potassium sulphate	0.228
Calcium sulphate	1.887
Sodium sulphate	93.230
Sodium chloride	1.990
Silica, alumina, and ferric oxide	0.036
Loss	0.017
Total	100.560

The spring from which this water is taken is situated in the Spanish Pyrenees, near Cervera, in the province of Lerida. As it has been so recently introduced to the notice of the medical profession in America, it is not

possible to speak with greater precision concerning the merits of the water. *T. L. S.*

RUE, OIL OF (*Oleum Rutæ,* U. S. Ph., Br. Ph.; *Rue,* Codex Med. [the flowering plant]). The essential oil of *Ruta graveolens* Linn.; Order, *Rutaceæ.* This is a perennial herbaceous or partly woody plant, two or three feet in height. It has pale green, cylindrical, branching stems, alternate, smooth, light-green, glandular-dotted leaves; the lower twice or three times pinnate, the intermediate once or twice pinnate, the uppermost simple. Divisions wedge-shaped, rounded, or blunt at the extremity. Flowers in a terminal corymb, with the parts in fours or fives; stamens twice as many; sepals small, pointed; petals large (one-half inch long), rounded, and hooded at the ends, narrow below, greenish-yellow. Pistil supported on a thick, fleshy disk; style single, ovary four- or five-lobed, with numerous ovules. Fruit a dry, dehiscent capsule. Rue is a native of Southern Europe, the Levant, etc., and is also cultivated; it has a strong, disagreeable odor, and a bitter, sharp taste. The oil only is officinal here.

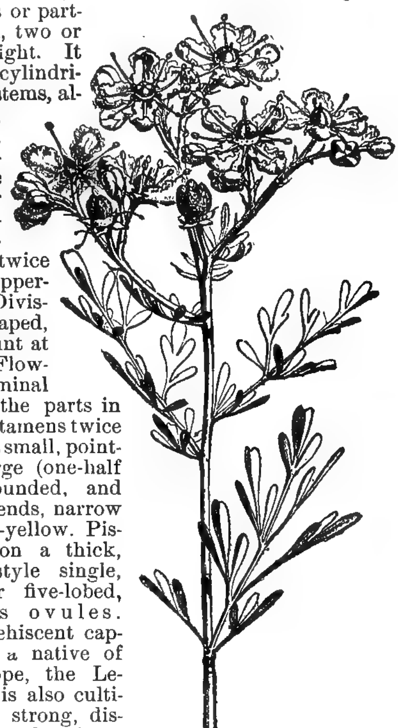

Fig. 3351.—Flowering Branch of Rue. (Baillon.)

Oil of Rue is obtained from the whole plant by distillation, the yield being about one-fourth of one per cent. It is "a colorless or greenish-yellow liquid, of a characteristic aromatic odor, a pungent, bitterish taste, and a neutral reaction. Specific gravity about 0.880. It is soluble in an equal weight of alcohol" (U. S. Ph.). Oil of Rue consists of a hydrocarbon and an oxygenated portion, the latter yielding pelargonic acid by decomposition. The leaves of Rue also yield a crystalline, neutral substance called *rutin,* which is found besides in several other plants. It is not active.

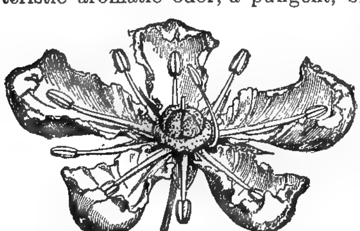

Fig. 3352.—Rue, the Flower. (Baillon.)

Oil of Rue is one of the more deleterious of the essential oils. Like turpentine, tansy, juniper, and others, it is externally quite irritating, and on this account is used in liniments and plasters. Given internally, it is an anthelmintic, "antispasmodic," and "emmenagogue," according to the older authorities, and was used in amenorrhœa, hysteria, and epilepsy; but it is scarcely given internally now. Dose from two to five drops.

Fig. 3353.—Fruit of Rue. (Baillon.)

Allied Plants.—The genus comprises about forty plants of Europe and Asia, none of the others of economic importance. The order is a large one, of mostly tropical plants, nearly all fragrant, and many of considerable importance in medicine, etc., as the following selections will show:

Ruta graveolens Linn., Rue.
Dictamnus albus Linn., Fraxinella.
Cusparia trifoliata Engl., Angustura.
Pilocarpus, several species, Jaborandi, Pilocarpine.
Barosma, several species, Buchu.
Xanthoxylum fraxineum Willd., Prickly Ash.
Toddalia aculeata Pers., Lopez Root.
Citrus, several species; Oranges, Lemons, Bergamottes, etc.
Aegle Marmelos Correa, Bael.

Allied Drugs.—Oils of Tansy, Cedar, Juniper, Turpentine, etc., have physiological properties somewhat like that of Rue. *W. P. Bolles.*

RUSCUS ACULEATUS Linn. (*Petit Houx ou Fragon épineux,* Codex Med.), a singular perennial, half-shrubby, liliaceous plant, with minute bract-like leaves and flattened leaf-like stems in their axes, looking almost exactly like leafy foliage excepting when the little flowers appear from the middle of their apparently upper surfaces. Its root is laxative, but scarcely used now.

W. P. Bolles.

Fig. 3354.—Ruscus Aculeatus; flowering branch. (Baillon.)

RYE (*Seigle,* Codex Med.), *Secale cereale* Linn. (*Triticum cereale* Archers); Order, *Gramineæ.* This important grain, standing nearer in some respects to wheat than the others, has, like them, been so long in cultivation as to have lost its early ancestry, and is not known wild. It will grow in colder latitudes than wheat, and on this account is the principal breadstuff in some of the northern parts of Europe. It is also extensively grown in the

northern States of this country and in British America. Eastern Asia is supposed to be its original home. Rye-flour is darker, grayer in color than that of wheat, and has a characteristic odor and taste. It is more laxative than wheat-flour, and makes a dark-colored, sweetish-sour bread (*Schwarzbrod*) very widely used on the continent of Europe, and among the Germans in this country. Rye consists of nearly sixty per cent. of *starch*, ten of *nitrogenous substances*, two of *fat*, four of *sugar* (synanthrose), seven or eight of *gum*, *dextrin*, etc., besides ten or more of water, and one or two of ash.

FIG. 3355.—Rye. 1, Inflorescence; 2, entire plant; 3, spikelets; 4, flower; 5, the same, after removal of the glumes; 6, grain. (Baillon.)

Rye is in no sense a medicine, but it has been with some people a favorite poultice material. It is also interesting as the "host" upon which ergot grows.

ALLIED PLANTS, ETC.—See STARCH. *W. P. Bolles.*

SACRO-ILIAC DISEASE. Syn., Sacro-coxitis (Hueter), Sacrarthrocace, Sacro-coxalgie. The ilio-sacral joint resembles the other articulations of the body in its anatomical structure, but differs from most of them chiefly in the limited amount of motion of which it is capable. It may be compared with the intervertebral articulations in this respect. Although this joint is called upon to support the weight of the trunk and upper extremities, in both the standing and sitting postures, it is, nevertheless, owing to the slight degree of motion possible, not so often the seat of traumatic lesions as might *à priori* be supposed. Yet it is probable that the joint more often feels the effect of slight traumatisms than is generally believed. The lumbar pains and backache experienced after long standing, walking, riding in a springless wagon over a rough road, or horseback exercise, are, in many cases, the result of slight injury, or tire, of the ilio-sacral articulation (Chauvel), although doubtless muscular strain is also often an important factor in their causation.

The joint is occasionally, though rarely, the seat of an acute inflammation, which runs its course rapidly, attended with high fever and suppuration, and which is apt to terminate in the death of the patient from exhaustion. The chronic form is much more often seen, though it is nevertheless comparatively rare. Chronic sacro-iliac disease is, however, notwithstanding the infrequency of its occurrence, and apart from its intrinsic importance, well worthy of careful study by reason of its liability to be mistaken for hip disease, spondylitis involving the lower segments of the spinal column, or other lesions of neighboring parts.

The lesions of sacro-iliac disease are similar to those accompanying chronic inflammation of other joints, for a description of which the reader is referred to the article entitled Joints, Chronic Diseases of, in the Appendix. There are three varieties usually described, viz., the tubercular, the puerperal (pyæmic), and the gonorrhœal or urethral. The possible occurrence of a fourth form, the syphilitic, may be admitted, but it is, at all events, extremely rare.

The tubercular form, which is by far the most common, begins usually as a fungoid synovitis, the morbid process extending later to the cartilage and bone; but occasionally the joint is invaded by the extension of a carious or necrotic process which had begun in the sacrum or ilium.

The disease is exceedingly rare in childhood, its period of greatest frequency being in early adult life. Men are more commonly its subjects than are women. In its etiology the tubercular form of sacro-iliac disease differs in no essential respect from a similar chronic arthritis occurring elsewhere. Chauvel asserts that the affection occurs with comparative frequency in young cavalry soldiers, and finds its exciting cause in the traumatism arising from the unwonted equestrian exercise. The etiology of the puerperal and gonorrhœal varieties is sufficiently indicated by the terms employed to designate them.

The symptoms of sacro-iliac disease are often obscure. They resemble closely those of Pott's disease of the lumbo-sacral region, or of morbus coxarius. Pain is a nearly constant symptom, though it varies much in degree, from a heavy, dull ache to an acute, agonizing pain, often increased beyond endurance by the slightest movement of the inflamed surfaces. Like the pain accompanying arthritis of other articulations, it is often intermittent and irregular in its exacerbations; it is aggravated by standing or sitting, but usually, though not always, relieved when the patient assumes the recumbent posture; it is apt, also, to be more severe at night than it is when the patient is at rest during the day. In severe cases the pain is increased by anything which causes movement of the articulation, even by sneezing or by the effort of defecation. Pressure over the sacrum, and any movement imparted to the innominate bone, as by approximation, separation, or twisting of the iliac crests, excites more or less pain; but gentle passive movements of the lower extremities, apart from direct upward impulses, usually cause no complaint if the pelvis be firmly held so as to prevent all movement at the ilio-sacral joint. There may be tenderness on pressure over the suspected joint, but this is not always

present. Sometimes it can be elicited by pressure on the anterior surface of the joint by means of the finger in the rectum. The pain is sometimes referred directly to the articulation affected, but may often be felt in the lumbar region, in the thigh, or even in the knee, and it may at times simulate sciatica so closely as to be mistaken for it.

Swelling is usually present at some stage of the disease, though this is not invariably the case. In the early stages, before an abscess has appeared, there may be a localized swelling in the neighborhood of the articulation, and at a later period the entire limb on the affected side may become œdematous. It is not rare, however, to encounter no appreciable swelling at any time during the course of the disease, except such as may be due to an abscess.

The appearance of an abscess is not uncommon, though suppuration is no more a necessary accompaniment of tubercular disease of the sacro-iliac joint than it is of a similar process occurring in other articulations. It is usually not until after the disease has existed for a considerable length of time that an abscess can be detected. The pus may present itself posteriorly over or near the articulation, sometimes forming a considerable tumor in the buttock, or it may, especially when it comes from the anterior portion of the joint, burrow in any direction and present itself as a cold abscess at some point more or less distant from its source. Thus it may open into the rectum, present itself as a tumor of the ischio-rectal fossa alongside the anus, appear in the back near the spine, or in the groin, or come to the surface on either the anterior or the posterior aspect of the thigh.

The temperature over the diseased articulation is elevated to a greater or less degree.

Atrophy of the muscles of the corresponding limb is invariably present, and usually in a very early stage of the disease, becoming more pronounced in proportion to the duration of the inflammatory process. The gluteal region is flattened, and the muscles are frequently soft to the touch and flabby.

The thigh may appear to be flexed and adducted, but in most cases, if not in all, this is not a real displacement, but is a consequence of malposition of the pelvis. The same is true of the apparent lengthening or shortening of the lower extremity, one or other of which, more commonly lengthening, is usually to be observed as a consequence of the obliquity of the pelvis. Sometimes there is a slight degree of outward rotation of the limb, so that the foot is turned more or less from the median plane of the body.

Limping is always present, though it may, at the outset of the disease, be intermittent or vary considerably in degree. The patient shows a hesitancy in allowing the weight of the body to rest on the affected side, and also moves the corresponding leg as little as possible. When it becomes necessary to transfer the weight to this side, the foot is placed carefully, the whole sole coming in contact with the ground as nearly as may be at the same moment, the heel and toe movement being avoided. The sound limb is then thrown rapidly forward, the patient meanwhile leaning heavily on his cane, and flexing the hip and knee slightly, as if to reduce as far as possible the force of the concussion. Then, when the body rests once more on the sound side, the other foot is raised slightly from the floor, and brought slowly and cautiously forward for a short distance, when it is again implanted evenly on the ground.

The position of the body when the patient is standing is also quite characteristic. In order to shift the centre of gravity as far as possible from the line of the diseased joint, the body is inclined strongly to the opposite side. The position may also afford relief, as has been suggested by Sayre, by making the weight of the limb on the affected side act as a traction force upon the inflamed articulation. This protective attitude may have its inconveniences, however, as lateral curvature of the spine may be produced as a result of its long continuance.

The diagnosis of a well-marked case of sacro-iliac disease is comparatively easy, if the points above detailed be borne in mind; but in an atypical case the recognition of the affection is sometimes exceedingly difficult, and mistakes in diagnosis are very easily made, unless the case is carefully studied.

The following table will bring out the differential points of sacro-iliac, hip, and spinal disease more clearly than could be done by a separate description of the symptoms of each one:

Sacro-iliac Disease.	Hip Disease.	Pott's Disease.
Is a rare disease.	Is a common disease.	Is not very common in the lumbo-sacral region.
Occurs usually in young adult males.	Occurs usually in childhood and in individuals of either sex.	Occurs more commonly in children, but is not rare in adults.
Motions of the hip are free.	Motion at the hip restricted in every direction by reflex muscular spasm.	Motion at the hip is free, except that extension and outward rotation are limited when there is psoas contraction.
The spine is not rigid, though it is often held stiff, as motion causes pain at the affected joint.	The spine is freely movable.	The spine is rigid at the seat of the lesion. In advanced stages there is more or less kyphosis.
Position is characteristic. Patient stands with the body inclined to the sound side.	Position is not characteristic, but varies with the stage of the disease and with the position of the thigh.	When loss of substance of the vertebral bodies has taken place, there is a forward inclination of the body.
The limb is apparently elongated (sometimes shortened), and there is not infrequently adduction.	The character of the deformity varies. There is real shortening, at least in the advanced stages.	The thigh may be flexed. Otherwise there is no malposition.
Cautious passive movements at the hip are painless. Severe pain is often excited by pushing together, separating, or twisting the wings of the ilia, or by pressure on the sacrum.	All movements of the hip cause pain. Motion of the sacro-iliac joint excites no complaint.	Movements of the hip painless. Pressure or the application of a hot sponge sometimes, though not always, causes pain.
The pain is usually localized near the affected joint, though it may be felt in the hip, knee, or thigh.	Pain is usually referred to the hip, knee, or middle portion of the thigh.	Pain is usually located in the back, but it may radiate down one or both thighs.
When a sinus is present, a flexible probe passes in the direction of the sacro-iliac joint.	Probe leads in the direction of the hip-joint.	Probing seldom aids, except in a negative way, in the diagnosis, as the abscess usually opens at a distance from the seat of the lesion.

In necrosis of the pelvic bones there may be a sinus leading in the direction of the ilio-sacral joint, but in uncomplicated cases there is no restriction to motion in any of the neighboring articulations, and no pain is excited by passive movements of these joints.

Sciatica may usually be easily discriminated by the fact that it is an affection of more advanced life than is sacro-iliac disease. The position of the patient is not characteristic; there is no deformity, except occasionally a slight degree of flexion of the hip and knee; motion of the suspected joints does not uniformly cause pain, and it is never restricted by reflex muscular spasm, as is the case in arthritis; and there is pain on pressure only over the course of the sciatic nerve.

Psoitis may simulate sacro-iliac disease, but it is more often mistaken for disease of the hip, or lower portion of the spine. The pain in this affection is increased by extension of the thigh, but is relieved by flexion, and all movements of the thigh which do not put the psoas muscle on the stretch are free. Pressing together, separating, and twisting the crests of the ilia, cause no pain. In psoitis there is flexion of the thigh, and if the body is inclined at all, it is toward the affected side rather than away from it. Finally, psoitis is attended with much more acute general symptoms than is uncomplicated sacro-iliac disease.

The possibility of neuromimetic joint disease should also be borne in mind in the endeavor to arrive at a correct diagnosis. For a general description of the nervous

mimicry of joint disease the reader is referred to the article on Neuromimesis, in vol. v. of this HANDBOOK.

Sacro-iliac disease runs a very slow and tedious course, being one of the most chronic of all chronic joint diseases. The patient is more or less incapacitated for any kind of work for a considerable length of time, since the sitting posture causes almost, if not quite, as much pain and inconvenience as does standing or walking. The prognosis, as regards life, is about the same as that in other forms of chronic joint diseases. Death may occur from exhaustion after prolonged suppuration, from renal complication, or from tubercular disease of other organs. Recovery, usually after a prolonged period of suffering, is, however, not uncommon.

The treatment of sacro-iliac disease, like that of other chronic joint affections, consists essentially in rest, traction on the inflamed articulation, and general tonic and supporting treatment. Hutchinson's method of the treatment of hip disease, by means of crutches and a high sole on the shoe on the sound side, answers better, in the writer's experience, for sacro-iliac disease than it does for the affection for which it was originally intended. For patients with sacro-iliac disease are older, as a rule, than hip patients; they understand the *rationale* of the method, and they are more careful not to discard the crutches and thump the foot down on the ground as soon as the disease begins to improve and the exquisite sensibility of the joint has disappeared. In certain cases, especially when the pain is very acute, the patient must be confined to the bed with a weight and pulley attached to the leg by means of a modified Buck's extension, such as is used in the application of an ordinary hip-splint.

Attention must, of course, be paid to the general health, for the patient has, at the best, to undergo a long siege; the disease is a debilitating one, and the sufferer must husband his strength to enable him to endure it.

Of local treatment by means of the injection of iodoform, or of calcium phosphate, as proposed and used by Kolischer, the writer is unable to speak from personal experience. But such methods, if as efficacious in the treatment of hip disease as is claimed, would seem to be particularly applicable to the treatment of tubercular disease of the ilio-sacral joint. *Thomas L. Stedman.*

SAFFRON (*Crocus*, U. S. Ph., Br. Ph., Ph.G.; *Safran*, Codex Med.). A perennial, colchicum-like herb, but with an inferior ovary. It arises from a flattened, fleshy corm, about three centimetres (one inch or more) in diameter, having a number of rootlets below and developing one or more buds upon its upper surface, which become new corms as the first one dies. It is covered with a few brown scales. From one or two of the buds a short stem arises, bearing a few long, linear, fleshy, shining green leaves. It ends near the surface of the ground in one or two flowers. These consist of an inferior ovary, of three cells, and a large, purple, bell-shaped perianth, with a very long (ten or fifteen centimetres), stem-like tube; divisions, six; stamens, three. This style is very long and slender, colorless excepting at the upper end, dividing finally into three long, recurved, stigmatic branches. Saffron grows wild in Southern Europe and the East. It is supposed to be a native of the Levant, but has been so long in cultivation that its exact geographical origin is in doubt. It is cultivated in several warm countries, especially in Spain, France, and Austria. Large quantities are also raised in different parts of Asia for home consumption. Saffron of excellent quality is produced in Pennsylvania, but scarcely on a commercial scale.

FIG. 3350.—Ovary of the Saffron Plant, Entire and in Transverse Section. (Baillon.)

Commercial saffron consists only of the stigmas, or these with as little of the upper end of the style as is practicable to get. It is collected by plucking the flowers as they open and carefully picking out these organs, which are then carefully dried with gentle heat. Seven or eight thousand flowers are said to be required for a hundred grammes of saffron. French saffron is said to be the best. Spanish is the most common.

DESCRIPTION.—The stigmas are now usually dried loosely tangled together, in a way that has given it the designation "hay saffron;" with a little shaking the individual styles can be shaken out without breaking. It is dry-feeling, but not brittle, and moderately hygroscopic. The officinal definition is as follows: Stigmas, separate, or three, attached to the top of the style, about

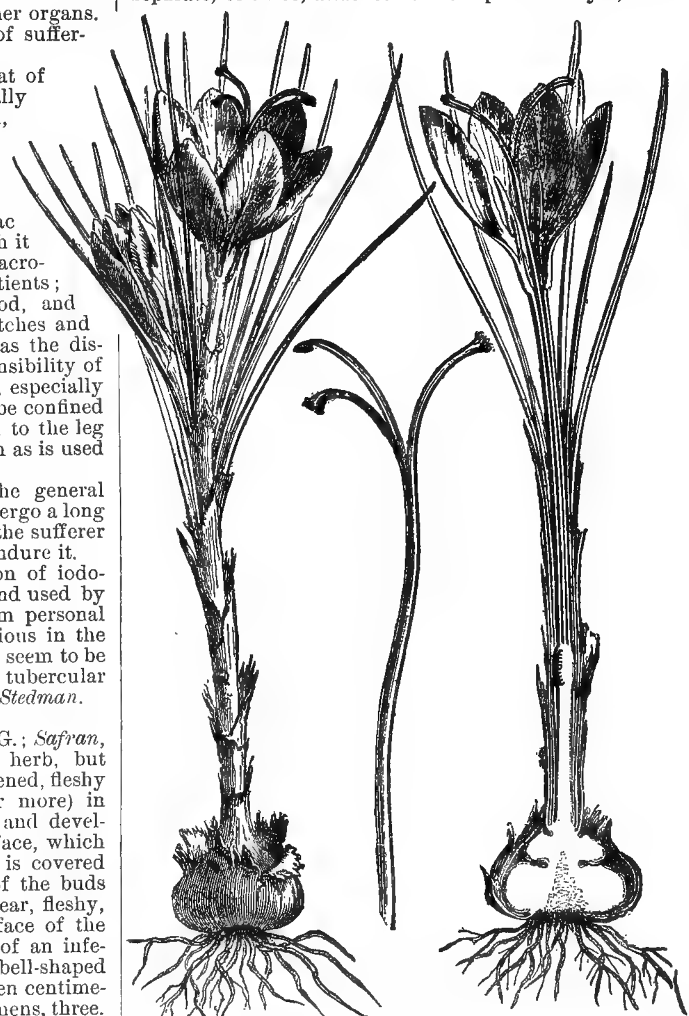

FIG. 3357.—Saffron Plant (one-half natural size); also Longitudinal Section of the same, and Style. (Baillon.)

an inch and a quarter (three centimetres) long, flattish-tubular, almost thread-like, broader and notched above: orange-brown; odor strong, peculiar, aromatic; taste bitterish and aromatic. When chewed it tinges the saliva deep orange-yellow.

The high price of this product has been the cause of many devices, nearly all of them very stupid and easily detected, to cheapen it; too much of the styles, which are worthless, may be gathered along with it; it may be mixed with stamens; the flowers of *Calendula* or other yellow *Compositæ* may be mixed in, or even substituted for it; or it may be weighted with water or oil, or colored chalk, or it may be partially exhausted. Soaking in warm water, examining with a lens, or pressing between sheets of blotting-paper will serve to detect these sophistications. The cheap drug, commonly called in domestic

parlance "saffron" in this country, is safflower, *Carthamus tinctorius* Linn., order, *Compositæ*. It is a favorite sudorific in measles, and popularly believed to favor the appearance of the eruption.

The history of saffron has a good deal of interest, since it was for centuries one of the most highly prized of drugs, a valuable dye, and a pleasant condiment or perfume. It has been known since the time of Solomon in the East, and almost as long in Asia Minor, Greece, and Italy. Its cultivation in Spain dates back seven or eight hundred years; in other parts of Europe from five to seven hundred. Its adulteration, almost as old as even its production, has always been a subject for governmental solicitude, and was punished by severe, in some countries cruel and barbarous, penalties. People have been buried alive and burnt for this crime. The uses of saffron also were much more varied, and deemed far more important, than we can imagine them now.

Composition.—Saffron contains about one per cent. of *volatile oil*, heavier than water and not very permanent, to which its odor is due. This oil appears to be variable both in quantity and properties, and is perhaps partly produced by decomposition of the crocin; Quadrat obtained an oil lighter than water; distilled with a solution of salt and potash, more than nine per cent. may be obtained (Husemann). It also contains a small amount of *gum*, fat, and *wax*. The important constituent, however, is its coloring matter, *Crocin* (polychroit), of which there is, according to Hager, sixty-five per cent. It is a deliquescent, orange-red, amorphous substance, having no odor, but a sweetish taste. Over sulphuric acid it can be dried to a bright red powder. Water and diluted alcohol dissolve it freely, absolute alcohol but little, ether not at all. By treatment with diluted acid it decomposes, and glucose and another coloring substance, *Crocitin* (crocin), are produced; this is a red powder, easily soluble in alcohol, but not in water or ether.

Action and Use.—This is the shortest paragraph in the article; as a medicine it probably has little or no value. In large doses, five to fifteen grammes (ʒ j. ad iv.), it is said to be abortifacient, in smaller ones emmenagogue and narcotic; but these properties are very uncertain, to say the least. In small doses it is moderately carminative, but no better than fifty different mints and umbellifers of about one-hundredth its cost. As a coloring agent it is superb, and has only recently been superseded by the marvellous development of the aniline series of dyes. It is still used, especially in Europe, to give color and flavor to a number of preparations. The tincture (*Tinctura Croci*, U. S. Ph.), strength $\frac{1}{10}$, is officinal.

Allied Plants.—Several other species of *Crocus* have strongly colored stigmas, and have been similarly used. *Gladiolus* and *Iris*, in the same order, are familiar names to the florist; the latter genus furnishes two or three medicines. See Orris and Flag, Blue.

Allied Drugs.—Crocin has been obtained from one or two other plants of no botanical connection with crocus. Carthamus, above-mentioned, resembles saffron slightly in color. Annato is another yellow-coloring substance, occasionally used in pharmacy, more frequently in the dairy. Red rose and cochineal give their superb colors to a few mixtures.

W. P. Bolles.

SAGE (*Salvia*, U. S. Ph.), *Salvia officinalis* Linn.; Order, *Labiatæ*. This is the well-known Garden Sage, a half-shrubby perennial, whose stems die down to within a foot or so of the ground in the fall, but branch very freely and send up numerous herbaceous, squarish, leafy, and flowering branches during the summer, twice or three times as long. Leaves numerous, those near the ground short-petioled, the upper ones nearly or quite sessile, thick, rugose, bluntly oval or oblanceolate, finely serrate. They are slightly pubescent above, often very woolly and white beneath. Flowers in a mixed spike, with two-lipped, pubescent, bell-shaped calyx, and a conspicuously labiate, blue corolla, with a ring of hairs at the base, inside. Upper lip of the corolla concave, notched at the apex, the lower three-lobed; the central one much the largest and longest. Perfect stamens two, with widely divergent anther-cells, but one of which in each stamen is perfect. Ovary four-lobed. Fruit of four achenes. Sage, like so many others of our household mints, is a native of Southern Europe. It has, however, been cultivated for centuries, and transplanted to all temperate countries. There are a few garden varieties. The flowers may be pale-blue, pink, or white, the leaves narrow, variegated, or curled.

Fig. 3358. — Salvia Officinalis, Sage; flowering branch. (Baillon.)

The leaves, or leaves and tops, are used. Dried Sage leaves have a grayish-green color, pubescent surface, and the peculiarities of shape and surface given above; they are one or two inches long, have large oil-glands upon their surfaces, and are very aromatic; taste bitter and slightly astringent.

Sage owes its very characteristic odor to less than one per cent. of a limpid greenish *essential oil*, a composite substance containing a hydrocarbon, one or more oxygenated oils, and a camphor—in short, resembling the oils of mint, patchouly, thyme, etc. It also contains a moderate amount of *tannic acid*, some *resin*, *gum*, *bitter extractive*, and common plant components.

Fig. 3359. — Flower of the Sage Plant. (Baillon.)

Their taste and odor divide the mints from each other more than chemical or therapeutic properties. Sage resembles the rest of the order in its general action; it is aromatic, a gastric stimulant, and by reason of its bitterness also tonic. It is also, what all are not, mildly astringent. In large quantities of hot water, like many other mints, it is given as a sudorific in the beginning of feverish colds, etc. Sage is useful in mouth-washes. It is, however, almost entirely a domestic remedy, and even as such but little used of late, although formerly in high repute. It is one of the ingredients of the aromatic wine (*Vinum Aromaticum*, U. S. Ph.), an old-fashioned liniment.

Allied Plants, etc.—See Peppermint.

W. P. Bolles.

SAGO (*Sagou*, Codex Med.). A starch prepared from the stems of several species of *Palmæ* growing in the Indian Archipelago, especially from *Metroxylon* (*Sagus*) *Rumphii* Mart., *M. læve* Mart., *Sagus farinifera* Lam., etc. The soft pithy stems of these palms, just before blossoming, are loaded with starch to such an extent that upon splitting them open it can be scooped out in a coarse, moist powder. This is then washed over sieves, and the cellular tissue thus separated. For European use the starch, which has passed through these strainers, is washed sufficiently, and then, while moist and thick, rubbed through a sieve. By this means it is formed into grains of the size of the meshes, which are dried in a hot pan,

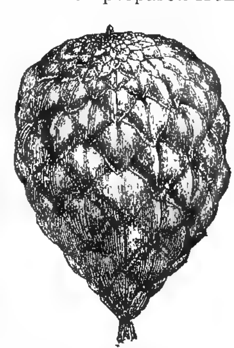

Fig. 3360.—Fruit of Sago Palm. (Baillon.)

and finally polished by friction in bags or rollers. Sago varies in appearance according to the details of this process. That most common in groceries in the United States is "Pearl Sago," in small round granules, about as large as white mustard seeds (1 mm. in diameter), white and opaque, or somewhat translucent, in places. Sago starch is in oblong, sometimes tuberculated, and angular granules, with a very excentric hilum, and frequently with separated protuberances, leaving sharply marked facets.

Sago is simply starch, and no more a medicine than arrowroot or tapioca See STARCH. *W. P. Bolles.*

SAINT-AMAND is a small city in the Département du Nord, France, in which are several mineral springs of some reputation. The place is frequented, however, chiefly by reason of the mud baths which are there given. The following is the composition of the mud:

	Grammes.
Water	55.000
Calcium carbonate	1.569
Magnesium carbonate	0.568
Iron	1.450
Sulphur	0.210
Silica	30.400
Organic matters	8.103
Loss	2.700
Total	100.000

The waters of the springs, which are used for drinking, contain sulphates of calcium, sodium, and magnesium, carbonates of calcium and magnesium, chlorides of sodium and magnesium, and silicic acid. No use is made of the water for bathing purposes. Saint-Amand is recommended chiefly for the relief of chronic and subacute rheumatic affections, of certain forms of neuralgia, and of lameness and disability following sprains or remaining as sequelæ of fractures and dislocations. A course of treatment here is also said to be of benefit in chronic congestive affections of the abdominal and pelvic organs. *T. L. S.*

SAINT-HONORE is a thermal station in the French Pyrénées, lying at an elevation of about 900 feet above sea-level. The waters of the several springs are slightly sulphuretted, and contain a large proportion of sodium chloride as compared with the other mineral constituents. The temperature of the different springs varies from 80° to 86° F.

A course of treatment at Saint-Honoré is recommended by writers to those suffering from catarrhal affections of any of the mucous membranes, incipient pulmonary phthisis, functional disorders of menstruation, and certain forms of eczema, lichen, pityriasis, and acne. In rheumatic affections baths are sometimes given, with the water heated above its natural temperature. *T. L. S.*

SAINT IGNATIUS' BEAN (*Ignatia*, U. S. Ph.). The seed of *Strychnos Ignatii* Berg, Order *Loganiaceæ*. This is a large, half-climbing shrub, with very long, slender branches, and rather large, oval, pointed, three-nerved leaves. The flowers resemble those of *S. Nux Vomica*, and the fruit is a very large (ten to twenty centimetres), solid, many-seeded, hard berry. Very little is known in detail concerning this plant. Bentley and Trimen, in their "Medicinal Botany," have been obliged to copy descriptions and figures from fifty to nearly two hundred years old, and there do not appear to be any accessible botanical specimens. It is even doubted by some whether it comes from a Strychnos at all, but the peculiar structure and composition of the seeds make this almost certain on indirect evidence. The plant grows in the Philippine Islands, and has been introduced into Cochin-China. The fruit appears to be not uncommon in some Asiatic markets. The seed has been known to Europeans since 1699 (Flückiger).

Saint Ignatius' Beans are hard, oblong but irregularly faceted seeds, two or three centimetres in length, of a dull yellowish-gray or blackish color, and corneous texture; they are normally covered with short, coarse, appressed, glistening hairs, but these are usually rubbed off before they reach this country, probably by the friction of the long voyage, or carriage. The seed consists mostly of perisperm, but contains an oblong embryo, six or eight millimetres in length, in a cavity near the centre. The seeds have but little odor, and a very bitter taste.

COMPOSITION.—*Strychnine*, to the extent of from one to one and a half per cent.; *brucine* from one-half to three-fourths per cent.; considerable albuminoid matters; no starch. These seeds, from chemical, structural, and physiological points of view, are qualitatively so exactly duplicates of Nux Vomica, that the reader is referred to that article for further information. An abstract (*Abstractum Ignatiæ*, U. S. Ph.) and a Tincture (*Tinctura Ignatiæ*, U. S. Ph.) are to be had at the pharmacies. *W. P. Bolles.*

SAINT JOHN'S BREAD (*Caroube*, Codex Med.). The fruit of *Ceratonia siliqua* Linn., order *Leguminosæ*, a medium-sized "Locust" of Southern Europe and the Levant, whose English name is derived from the tradition that it formed part of the food of The Baptist while in the desert. It consists of pods of an oblong-linear, curved outline, ten or fifteen centimetres (four to six inches) long, two or three broad, and about one (or less) thick. They have a dull-glossy brown surface, and a sweetish, dry-pulpy texture. The pea-like, but slightly albuminous seeds, are imbedded in this pulp.

St. John's bread has no medicinal value whatever. It forms a poor article of food in Spain, Italy, etc., and is also fed to cattle. In this country it is scarcely to be met with, excepting at a few shops in the larger cities, where it is kept to supply a slight demand of Spanish and Italian immigrants.

ALLIED PLANTS, ETC.—See SENNA, CASSIA FISTULA, etc. *W. P. Bolles.*

SAINT JOHN'S WORT (*Millepertuis*, Codex Med.). *Hypericum perforatum* Linn., order *Hypericaceæ*. A troublesome weed, with a much-branched, herbaceous stem, somewhat flattened, from thirty to sixty centimetres high, elliptical-oblong, dotted leaves, acrid juice, and numerous rather showy, regular, yellow flowers. Sepals five, lanceolate-pointed. Petals five, large, rounded. Stamens numerous, in five bundles. Styles three, pod three-celled.

This and other Hypericums have had in time past considerable reputation in diarrhœa, rheumatism, insanity, etc., as well as in the form of liniments as vulneraries. All are at present obsolete, excepting in domestic use. *W. P. Bolles.*

SAINT LOUIS. The accompanying chart, representing the climate of the city of St. Louis, Mo., and obtained from the Chief Signal Office at Washington, is here introduced for convenience of reference. A detailed explanation of this chart, and of other like charts published in the HANDBOOK, is given in the general article on Climate, where also the reader will find suggestions as to the best method of using these charts.

St. Louis has one of the most extreme climates to be found within the limits of the United States. In illustration of this fact the reader is referred to the data of column J. By comparing the St. Louis and New York City charts we learn that although the mean temperature in winter at St. Louis is only two and a half degrees higher than that of New York, the mean summer temperature of the former is five and one-third degrees higher than that of the latter. The daily range of temperature is decidedly greater at St. Louis than at New York; yet, despite this fact, the day and night figures are in summer both of them so high that cooler nights are to be found at New York with a relatively low nycthemeral range of temperature. Column K shows us that month by month throughout the year the St. Louis climate is drier than the climate of New York. Columns L, M, and N show that the former is less cloudy, especially in summer and autumn, than is the latter. The prevalence of south winds throughout the year is a notable feature of the St. Louis climate; the blizzards of

Climate of St. Louis, Mo.—Latitude 38° 38′, *Longitude* 90° 12′.—*Period of Observations, January* 1, 1871, *to December* 31, 1883.—*Elevation of Place of Observation above the Sea-level,* 485 *feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	27.8	36.2	31.1	31.7	45.7	21.7	38.7	22.9	72.0	48.0	23.0	—16.0	24	31
February...	31.1	41.3	36.0	36.1	43.9	26.0	45.5	28.4	73.2	61.0	27.0	– 3.0	21	[illegible]
March	37.2	49.2	42.9	43.1	53.9	37.8	53.5	36.7	82.0	62.0	34.0	8.0	25	26
April.......	48.9	62.2	54.4	55.1	61.3	47.6	65.8	47.5	87.5	78.0	43.0	22.0	18	18
May........	60.6	73.0	64.8	66.1	70.8	59.5	75.4	56.7	93.0	84.0	45.0	32.0	25	25
June.......	69.6	81.1	73.4	74.7	79.7	71.9	83.0	65.2	99.0	90.0	64.0	48.0	16	19
July	73.7	85.3	77.4	78.8	81.7	73.8	88.2	70.0	104.0	93.0	70.0	57.0	22	21
August.....	71.0	84.0	75.7	76.9	82.5	72.8	87.4	68.3	106.4	87.0	63.0	55.0	25	22
September .	61.5	75.7	67.0	68.0	75.3	64.9	79.2	60.0	101.5	85.0	51.0	40.0	25	19
October	51.2	65.0	56.4	57.5	62.3	52.0	68.4	51.2	90.0	80.0	42.8	25.0	23	21
November..	37.7	47.7	42.0	42.4	49.6	31.9	52.1	36.6	82.0	61.0	31.0	5.0	24	23
December ..	30.3	38.4	34.1	34.2	47.9	24.9	43.4	29.0	74.0	53.0	21.0	—17.0	22	24
Spring......	....	....	....	54.7	60.1	51.9	....	....	....	....	....	....	....	....
Summer....	....	....	....	76.8	79.5	73.6	....	....	....	....	....	....	....	....
Autumn....	....	....	....	55.9	60.0	50.9	....	....	....	....	....	....	....	....
Winter......	....	....	....	34.0	41.9	26.4	....	....	....	....	....	....	....	....
Year........	....	....	....	55.3	57.5	53.6	....	....	....	....	....	....	....	....

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall in inches.	Prevailing direction of wind.	Average velocity of wind in miles, per hour.
January...	88.0	71.2	11.3	8.8	20.1	2.19	S.	10.2
February..	76.2	69.5	10.5	8.5	19.0	3.10	S.	10.3
March.....	74.0	66.0	11.9	7.7	19.6	3.04	N. W.	11.6
April......	65.5	59.7	11.8	9.4	21.2	3.35	S.	10.7
May	61.0	64.2	11.5	9.8	21.3	3.86	S.	9.7
June.......	51.0	68.2	14.4	8.0	22.4	4.82	S.	8.9
July.......	47.0	67.9	12.9	11.4	24.3	4.36	S.	7.7
August	51.4	66.1	13.2	14.1	27.3	2.56	S.	7.4
September.	61.5	64.7	10.9	13.9	24.8	2.55	S.	8.5
October....	65.0	64.9	11.8	12.8	24.6	2.17	S.	9.5
November.	77.0	67.9	12.2	7.7	19.9	2.79	S.	10.6
December .	91.0	72.0	11.2	7.2	18.4	2.19	S.	10.2
Spring.....	85.0	63.3	35.2	26.9	62.1	10.25	S.	10.7
Summer...	53.4	67.4	40.5	33.5	74 0	11.74	S.	8 0
Autumn...	96.5	65.8	34.9	34.4	69.3	8.12	S.	9.5
Winter.....	91.0	70.9	33.0	24.5	57.5	7.48	S.	10.2
Year.......	123.4	66.8	143.6	119.3	262.9	37.59	S.	9.6

March alone interfering to change the direction from S. to N. W.

H. R.

SAINT MORITZ. The climate of Saint Moritz, considered as a winter health-station, has already been sufficiently described in the article entitled Engadine. In the present article a few words will be said concerning the summer climate of this celebrated resort of the High Alps, and concerning its valuable mineral springs. The wood-cuts on page 246 (Figs. 3361 and 3362), copied from Woldemar Kaden's "Baths of St. Moritz," are presented to the reader as illustrations of the descriptive passages in the Engadine article, where they would have been more properly introduced had they been available to the writer when that article was prepared for press. These illustrations will be especially interesting to a reader of Dr. Yeo's work on "Climate and Health-resorts," and if studied in connection with the lengthy and interesting descriptions of scenery therein given, will convey to the mind a very accurate impression of the topography and scenery of the Upper Engadine.

In studying the illustrations it should be borne in mind that the direction of the Upper Engadine valley is from southwest to northeast.

The view in Fig. 3361 is taken from an elevated point on the eastern side of the valley, just south of the St. Moritz bathing establishment, and shows the valley as seen on looking north from this point. In the foreground are seen the Kurhaus, bathing establishments, and hotels constituting St. Moritz Bad, or the Baths of St. Moritz. Near the centre of the picture is seen the village of St. Moritz, built upon the northern slope of the valley, at an elevation of some two to three hundred feet above the lake of the same name. The mountains which close in the view to the north are a portion of the range of the Albula and Bündner Alps, the lofty serrated peak seen directly in line with the village of St. Moritz and towering above all other summits visible in the picture being the Piz Kesch (11,211 feet high above sea-level; 5,411 feet above St. Moritz Lake).

In Fig. 3362 the view is taken from an elevated point on the western side of the valley, just north of the village of Campfer; probably from the "summer restaurant known as the Alpina," mentioned by Dr. Yeo (*op. cit.*, p. 192). In this view we are looking up the valley, instead of down the valley as in Fig. 3361. The baths of St. Moritz are behind us on the left: and not very far distant either; for Dr. Yeo, in describing Campfer, tells us that "it is a convenient abode for those visitors to the Baths of St. Moritz who would be at St. Moritz, but not of St. Moritz," being "as near the Kurhaus and the baths as the village of St. Moritz itself." It is the village of Campfer that is seen in the immediate foreground of this picture. The little village standing in the distance is that of Silva Plana. The lake in the foreground is that of Campfer, the one in the background beyond Silva Plana is the lake of Silva Plana. The lake of Sils, the village of Sils, and the Maloja we do not see; they are hidden behind the mountain-shoulder which rises behind Silva Plana; but the great snow-covered alp which closes in the view to the southwest is the Piz Margna, one of the three Bernina mountains whose slopes are said by Dr. A. T. Tucker Wise to abut on the lake of Sils and on the eastern side of the Maloja plateau ("The Alpine Winter Cure," p. 66). The elevation of the Piz Margna above sea-level is 10,355 feet. A reader of Dr. Yeo's book will easily recognize another prominent object in this picture, namely, the location of "the restaurant and summer house called *Crest-alta*, which is finely situated on the top of a wooded promontory which projects in the most picturesque manner from the south side of the valley into the Campfer lake." This promontory is seen just to the left of the centre in our illustration.

SUMMER CLIMATE.—The following tables, taken from Woldemar Kaden's interesting pamphlet, will serve

Fig. 3361.—Baths and Village of St. Moritz. (From "The Baths of St. Moritz," by Woldemar Kaden.)

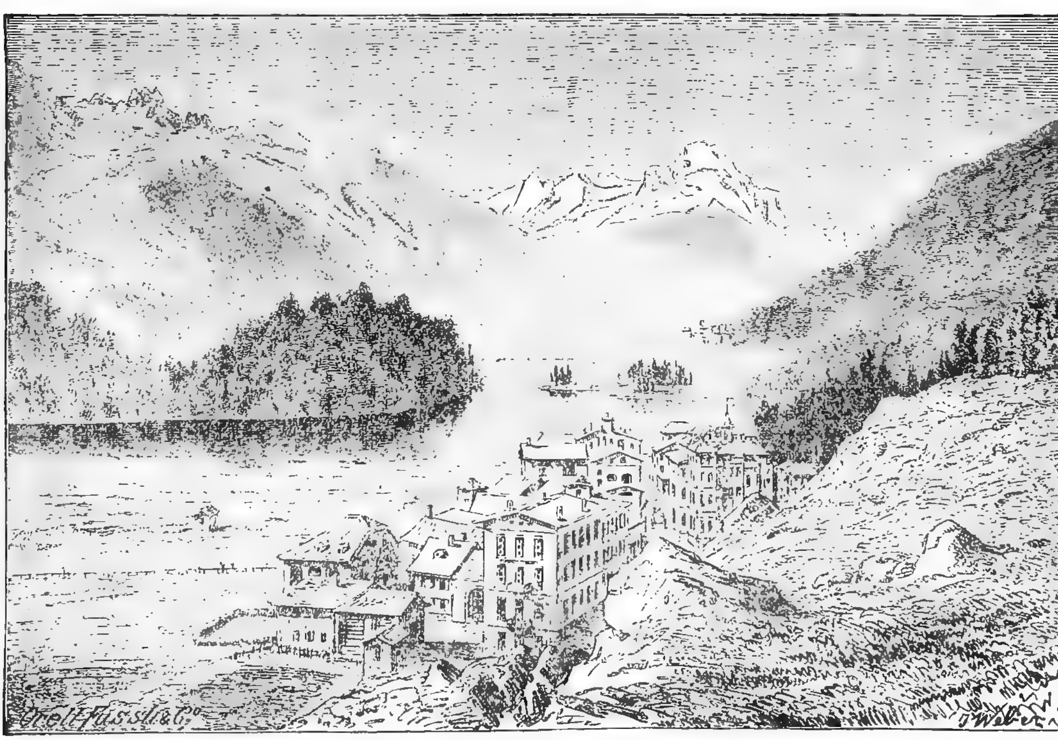

Fig. 3362.—Campfer, near the Baths of St. Moritz and Piz La Margna. (From "The Baths of St. Moritz," by Woldemar Kaden.)

sufficiently to illustrate the summer climate of Saint Moritz:

TABLE A.—*Mean Temperatures of the Summer Months and of the Season during the Ten Years* 1856–1865, *according to Professor C. Brugger.* (*"The Baths of Saint Moritz."*)

Month.	5 A.M.	1 P.M.	9 P.M.	Mean daily temperature.	Daily fluctuation of temperature.
June	41.57	57.27	44.74	49.55	15.69 (?)*
July	43.55	61.28	49.35	52.46	49.67
August	42.98	60.62	48.70	51.67	49.64
September	38.64	54.23	43.16	45.60	47.48
Season (June 21st to September 20th)	42.31	59.43	44.07	50.63	49.01

TABLE B.—*Mean Temperatures of the Summer Months and of the Season during the Seven Years* 1867–1873 (*Dr. Husemann, from Candrian's Daily Observations*). (*"The Baths of Saint Moritz."*)

Month.	7 A.M.	1 P.M.	9 P.M.	Mean daily temperature.	Daily fluctuation of temperature.*
June	45.95	55.61	44.74	48.74	43.89
July	50.79	62.43	47.87	54.57	45.39
August	46.92	59.50	48.11	51.51	45.86
September	40.38	54.96	41.00	46.45	47.33
Season (June 21st to September 20th)	47.31	59.77	48.30	51.80	45.89

* Whether the figures in this column represent the mean, or the extreme daily, fluctuations I do not know.—H. R.

TABLE C.—*Average of the Weather Conditions for the Summer Months and the Season during the Fourteen Years* 1860–1873 (*Dr. Husemann, from Candrian's Observations*). (*"The Baths of Saint Moritz."*)

Month.	Cloudless on days.	Cloudy on days.	Fog on days.	Rain on days.	Snow on days.	Thunder on days.
June	17.9	12.1	1.4	7.2	0.93	1.4
July	21.9	9.1	3.3	7.5	0.07	3.7
August	21.5	9.5	3.3	7.4	0.36	2.2
September	21.4	8.6	5.4	6.1	1.36	0.8
Season (June 21st to September 20th)	63.9	28.1	10.8	21.4	1.57	7.6

Mr. Kaden states that July and August are the best months for a summer stay at Saint Moritz, and that April and May, being the snow-melting months, are the very worst season of the year in the Engadine.

MINERAL WATERS.—There are two chief mineral springs at the baths of Saint Moritz, known respectively as the "Alte-Quelle" and the "Paracelsus-Quelle;" of these the latter appears to be a trifle the richer in mineral ingredients, but the two are very similar one to the other. A very full analysis of the two waters may be found on pages 58 and 59 of Mr. Kaden's pamphlet. Dr. Yeo (*op. cit.*, p. 160) also gives an analysis of the Saint Moritz waters. He sums up the characteristics of the waters as follows: "Practically these waters may be regarded as containing a small quantity of iron, about three grains of the carbonate in a gallon of the stronger source, and a considerable amount of carbonate of lime, about eighty grains in a gallon, held in solution by an abundance of carbonic acid. The presence of this large amount of carbonate of lime in the absence of any appreciable amount of aperient saline constituents, interferes somewhat with the usefulness of this water in many cases where the use of a chalybeate is indicated." The duration of the course of treatment by baths, etc., usually recommended, is from three to eight weeks. For full information concerning the proper use of the waters and the class of maladies ameliorable by such proper use, as well as the type of disease and of constitution indicating the propriety of recourse to this "high altitude" bathing-station, and the class of invalids and type of constitution which should be forbidden to resort thither, see Dr. Yeo's book and Mr. Kaden's pamphlet, in both of which works (the former especially) these matters are treated ably and at very considerable length. For general indications see articles "Health-resorts" and "Mountain Resorts."

Huntington Richards.

SAINT-OLAFSBAD is a health-resort in Sweden, not far from the city of Christiania, which is visited to some extent by foreigners on account of its iron-spring. This water contains 0.114 Gr. of mineral constituents, about fifty per cent. of which is ferrous carbonate, in each litre. There are various other "cures" made use of, such as pine-needle baths, mountain climbing, frictions with peat, milk and whey cures, etc.

The affections for the relief of which Saint-Olafsbad is visited are anæmia, chronic bronchitis, chronic rheumatism, debility attending tedious convalescence from acute diseases, etc. The place is well protected against the north winds, and the climate is more mild than in other places in the vicinity. The season for guests lasts from about the end of May to the first of September.

T. L. S.

SAINT PAUL. The accompanying chart, representing the climate of the city of Saint Paul, Minn., and obtained from the Chief Signal Office at Washington, is here introduced for convenience of reference. A detailed explanation of this chart, and of other like charts published in the HANDBOOK, may be found in the general article on Climate; where also suggestions are made as to the best method of using these charts. St. Paul and other points in Minnesota were greatly in vogue a few years ago as winter resorts for persons in the early stage of pulmonary phthisis, and very many such persons have no doubt been benefited by residence in the steady cold of the Minnesota winter; but, since the somewhat over-rapid growth of its chief towns has set in, and since the discovery of other and better climates of the bracing winter type, the reputation of Minnesota as a health-resort has considerably declined.

A comparison of columns L, M, and N of the St. Paul chart with corresponding columns of the New York City chart, demonstrates the fact that during the winter and summer seasons a less degree of cloudiness prevails at the former than at the latter station. During the spring season, on the contrary, New York City appears to be slightly less cloudy than St. Paul. The spring, fall, and winter rainfall at St. Paul is greatly less than at New York. In the matter of windiness the climates of the two places are very much alike in spring, summer, and autumn; but in winter the slight difference (in favor of St. Paul) existing between the two becomes very considerable, New York City, according to the figures of column S, being nearly twenty-three and two-thirds per cent. more windy at that season than is St. Paul. In the matter of relative humidity the climates of the two places are in winter almost precisely alike, such trifling difference as exists being in favor of New York City; in summer and autumn scarcely any difference between the two exists. In spring, however, and notably in the two months of March and April, the relative humidity at St. Paul is markedly less than at New York City. The absolute humidity of St. Paul, during the winter season in particular, is less than that of New York City, being at that season only half as great. In summer the two places differ little in absolute humidity of atmosphere. The actual figures for the two places are as follows, assuming for convenience of calculation that the mean summer temperature of New York is 0.5°, and that of St. Paul 0.6° higher than the actual figures, and that in winter New York City's mean temperature is 0.6°, and St. Paul's 0.4° higher than shown by the figures of Column AA.

	Mean summer temp.	Mean summer abs. humidity.	Mean winter abs. humidity.	Mean winter temp.
New York City	72°	5.973	1.537	32°
St. Paul	70°	5.586	0.823	17°

Climate of Saint Paul, Minn.—Latitude 44° 58′, *Longitude* 93° 3′.—*Period of Observations, November* 1, 1870, *to December* 31, 1883.—*Elevation of Place of Observation above the Sea-level,* 762 *feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	8.8	17.7	12.4	12.9	26.2	0.8	24.3	4.8	49.0	23.0	−11.0	−31.0	27	26
February....	12.8	24.7	17.8	18.4	31.8	6.9	29.4	9.4	59.0	24.0	5.0	−32.0	21	28
March......	22.6	34.7	28.3	28.5	44.3	21.5	41.2	22.2	68.0	46.0	21.0	−22.5	25	30
April.......	37.9	51.8	43.7	44.4	50.9	36.9	58.3	36.9	82.0	63.0	30.0	7.0	19	11
May........	53.1	66.1	57.2	58.8	63.8	52.2	68.7	48.3	94.0	75.0	40.0	24.0	24	25
June........	61.5	73.7	65.1	66.7	73.0	63.3	78.1	57.9	94.0	85.0	52.0	39.0	17	20
July........	65.9	79.6	69.9	71.8	74.6	66.6	82.8	62.7	100.0	91.0	57.0	46.0	26	21
August.....	63.5	77.8	68.0	69.7	72.9	66.1	82.0	61.5	98.0	88.0	54.0	43.0	21	24
September..	52.2	66.2	57.0	58.4	64.1	53.7	70.7	50.7	94.0	76.0	41.0	30.0	23	19
October.....	41.9	53.5	45.3	46.9	56.9	42.5	57.6	41.0	87.0	67.0	32.5	15.0	22	19
November..	26.4	34.8	29.3	30.1	39.6	22.2	40.2	23.8	72.0	47.5	15.0	−24.5	20	24
December..	15.2	22.8	18.1	18.7	33.6	8.2	28.2	12.2	56.0	36.0	10.0	−39.0	24	30
Spring......	......	......	......	43.9	47.1	39.5	......	......	......	......	....	....	......	......
Summer....	......	......	......	69.4	71.3	66.9	......	......	......	......	....	....	......	......
Autumn....	......	......	......	45.1	49.6	40.8	......	......	......	......	....	....	......	......
Winter......	......	......	......	16.6	29.2	8.7	......	......	......	......	....	....	......	......
Year........	......	......	......	43.7	48.2	39.8	......	......	......	......	....	....	......	......

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind, in miles, per hour.
						Inches.	From	Miles.
January....	80.0	72.1	13.0	8.0	21.0	1.07	N.W.	7.8
February ..	91.0	70.7	10.4	8.8	19.2	1.07	S.E.	8.2
March......	90.5	69.0	12.0	8.3	20.3	1.64	N.W.	9.2
April.......	75.0	60.3	12.0	8.2	20.2	2.09	N.W.	9.6
May........	70.0	60.5	14.2	8.8	23.0	3.72	S.E.	9.6
June.	55.0	68.0	15.2	8.2	23.4	5.13	S.E.	8.5
July........	54.0	69.9	15.8	10.6	26.4	3.22	S.E.	7.2
August.....	55.0	71.8	14.8	10.5	25.3	3.83	S.E.	7.3
September.	64.0	70.7	13.8	9.1	22.9	3.26	S.E.	8.2
October....	72.0	69.4	12.2	10.4	22.6	2.21	S.E.	8.8
November..	96.5	72.0	13.7	6.5	20.2	1.42	N.W.	8.3
December..	95.0	74.3	12.8	8.8	21.6	1.28	N.W.	7.5
Spring	116.5	63.3	38.2	25.3	63.5	7.45	N.W.	9.5
Summer ...	61.0	69.9	45.8	29.3	75.1	12.18	S.E.	7.7
Autumn ...	118.5	70.7	39.7	26.0	65.7	6.89	S.E.	8.4
Winter.....	98.0	72.4	36.2	25.6	61.8	3.42	N.W.	7.8
Year	139.0	69.1	159.9	106.2	266.1	29.94	S.E.	8.4

It is in the matter of temperature that we find the chief difference between the climates of the two places. The mean temperature of November at St. Paul is the same as that of January at New York City; while the mean temperature of the four months, December, January, February, and March is at New York 32.8° F., at St. Paul only 19.6° F.

Steady cold in winter, involving exemption from thaws, is the chief cause of the popularity formerly enjoyed by Minnesota as a resort for phthisical patients, and is the leading factor in its climate (combined with relative windlessness and cloudlessness, and its inland location, involving freedom from the perpetual changes from land to sea air, and from sea air to land air, common along the Atlantic coast), which renders the truly and purely continental climate of that State more favorable to weak lungs than is the climate of any of the larger seaboard cities of the Northern United States. *H. R.*

SAINT-SAUVEUR is a little hamlet in the Département des Hautes-Pyrénées, France, lying at an elevation of 2,500 feet above the sea. The valley in which the village lies is exposed to the north and south winds, but the climate is nevertheless equable and mild. There are two principal springs—the Source des Bains or des Dames, and the Source de Hontalade. The following is the composition of the waters, after analyses made by Filhol and Byasson. In 1,000 parts of water there are of

	Source des Bains.	Source de Hontalade.
Sodium sulphate	0.0400	0.0213
Calcium sulphate	......	0.0572
Magnesium sulphate	......	0.0087
Sodium sulphide	0.0218	0.0197
Sodium hyposulphite	......	0.0028
Sodium chloride	0.0695	0.0600
Sodium silicate	0.0704	0.0896
Calcium silicate	0.0062	0.0076
Magnesium silicate	0.0031	......
Aluminium silicate	0.0070	......
Organic matter	0.0320	0.0215
Total	0.2500	0.2884

There are traces of iodine and boracic acid. The waters issue at a temperature of 94° and 71° F., respectively.

The indications for a course of treatment at Saint-Sauveur are stated to be catarrh of the bladder, gravel, gastralgia, chronic diarrhœa, menstrual disturbances, certain uterine affections, pulmonary phthisis, and irritable conditions of the nervous system. The therapeutic means employed are baths, both general and local, douches, and the internal use of the water. The season extends from about the first of June to the middle of September. A single course of treatment generally occupies about four weeks. *T. L. S.*

SALEP, Codex Med. (*Tubera Salep,* Ph. G.). The corms of several European and Asiatic *Orchidaceous* plants, especially of *Orchis mascula* Linn., *O. Moris* Linn., *O. militaris* Linn., *O. variegata* Linn., etc., dried by means of artificial heat. It is in the form of small round, oval, or irregular tubers of a yellowish color and rather translucent texture. Salep is tough and hard to pulverize; it has a mucilaginous taste and very little odor; consists of a small quantity of starch and a good deal of bassorin-like gum, with no more active ingredients, and is simply a not very nutritious food, devoid of physiological or therapeutic value.

ALLIED PLANTS.—See VANILLA.
ALLIED DRUGS.—See TRAGACANTH; STARCH.

W. P. Bolles.

SALICYLIC ACID AND SALICYLATES. Salicylic acid, chemically *ortho-oxybenzoic acid,* $HC_7H_5O_3$, takes its name from the principle *salicin,* found in willow-bark, from which substance it is possible to make salicylic

acid by fusion with potassic hydrate. Salicylic acid in the condition of the ethereal salt, *methyl salicylate*, constitutes about ninety per cent. of oil of gaultheria (wintergreen), and occurs also in other plants. Salicylic acid can be made from oil of gaultheria, but at present almost all the acid used in medicine is made by the process of Kolbe, from carbolic acid. The principle of this process consists in the forcing upon the molecule of carbolic acid a molecule of carbon dioxide, an addition which just converts one molecule of the phenol into one of salicylic acid. By the process, carbolic acid and a concentrated solution of soda are first evaporated to dryness, and over the product, heated, a stream of dry carbon dioxide is made to pass. As a result, one half of the phenol used is converted into salicylic acid in condition of sodic salicylate, which salt, on decomposition by treatment of its aqueous solution with hydrochloric acid, yields salicylic acid under its own form. Kolbe's process, by reason of its cheapness, has practically superseded all others for the procurement of salicylic acid. Salicylic acid is officinal in the U. S. Pharmacopœia under the title *Acidum Salicylicum*, Salicylic Acid. It presents itself as "fine, white, light, prismatic, needle-shaped crystals, permanent in the air, free from odor of carbolic acid, but sometimes having a slight aromatic odor, of a sweetish and slightly acrid taste, and an acid reaction. Soluble in 450 parts of water, and in 2.5 parts of alcohol at 15° C. (59° F.); in 14 parts of boiling water; very soluble in boiling alcohol; also soluble in 2 parts of ether, in 2 parts of absolute alcohol, in 3.5 parts of amylic alcohol, and in 80 parts of chloroform. When heated to about 175° C. (347° F.) the crystals melt, and at about 200° C. (392° F.) they begin to sublime; at a higher temperature they are volatilized and decomposed with odor of carbolic acid. The aqueous solution is colored intensely violet-red by test-solution of ferric chloride" [one part of ferric chloride dissolved in ten parts of distilled water] (*U. S. Ph.*). Although salicylic acid is but feebly soluble in cold water, it dissolves freely in many saline solutions. Thus the pharmacopœial *solution of acetate of ammonia* will dissolve twenty-five per cent. of salicylic acid; a twelve and a half per cent. aqueous solution of potassic acetate will dissolve twelve and a half per cent. of the acid; a twelve and a half per cent. solution of potassic citrate in equal volumes of glycerin and water will dissolve six per cent. All of these solutions possess the sharp stinging taste of the uncombined acid. A serviceable and permanent solution of the acid, and one that instead of being sharp to the taste has a pure bitter flavor only, can be made as follows: Dissolve two parts of borax in twelve of glycerin by the aid of heat; add one part of salicylic acid, continue the heat, and stir until the acid dissolves. Almost all solutions of salicylic acid, either immediately or after a while, turn of a reddish or of a smoky color resembling that of solutions of carbolic acid.

Salicylic acid, taken into the mouth, has not much taste, proper, but speedily and quite suddenly after the tasting a sharp stinging seizes the *throat*, often severe enough to bring tears to the eyes. Similarly, a little of the dry acid snuffed up the nostrils will sting quite strongly. The acid brings sharp pain to cuts and abrasions, but, swallowed, is much less irritant to the stomach than its effects on the throat would lead to suppose. Large doses, so taken, may upset digestion and cause a strong sensation of heat, and even actual burning pain, but no serious or lasting results follow. The acid is rapidly absorbed from the stomach into the circulation, presumably in saline combination, and thereupon exerts the peculiar influence characteristic of the salicylates (see *Salicylates*, below).

Salicylic acid was at first used as an internal medicine for the procurement of the therapeutic effects of the salicylates; but now, and very properly, salicylates themselves, because of their freedom from the locally irritant action of the uncombined acid, have superseded the acid for this purpose. The present medicinal application of the acid is for local purposes as a deodorant, detergent, or so-called antiseptic—purposes which salicylic acid fulfils by reason of its possession of a fairly potent germ-sterilizing faculty. (See Salicylic Acid in article Germicides.) For general local use, the solution of the acid in a glycerin solution of borax is convenient, this solution bearing any necessary dilution with either water or alcohol without precipitation. A dilution representing a two per cent. solution of acid is one very commonly employed. For other salicylic preparations for local use, see Salicylic Acid in article Antiseptics.

Salicylates.—In saline combination, whether with metallic or ethereal bases, the local pungency of free salicylic acid disappears while yet the faculty for constitutional action remains. As already said, it is probable that the acid, when taken as an internal medicine, enters the circulation only after conversion into a salicylate, so that, as a matter of fact, what is commonly called the constitutional action of salicylic acid is, so far as we know, the action of a salicylate. The constitutional effects in question are as follows: After a full dose a non-pyrexial subject experiences, in about fifteen minutes, a moderate reddening of the face with a sense of fulness of the head, or perhaps even a pronounced headache, and with a buzzing or roaring in the ears precisely similar to what occurs in cinchonism. Almost simultaneously free perspiration begins, and, according to dose, there is more or less tendency to a reduction of pulse-rate, of respiration-rate, and of body-temperature. Tests for salicylic acid will reveal the presence of the substance in the urine, the saliva, and the sweat. The urine will furthermore be discolored, appearing brown by reflected, and green by transmitted, light. It will also contain a something that will reduce copper salts in copper test-solutions (Brunton). In overdoses, salicylates readily irritate the kidneys, setting up albuminuria; may derange the cerebral faculties, causing hallucinations and delirium; and may dangerously or even fatally depress the functions of heart and lungs, determining collapse or death by failure of respiration. These several untoward effects vary a great deal in readiness of occurrence, and, according to Squibb, in "a very large proportion" of instances are determined, not by the salicylic acid, but by a *contaminating acid* very commonly present in market samples of salicylic acid, and hence in salicylates derived therefrom. The medicinally valuable constitutional effects of salicylates do not appear in experimentation with a subject in health. They consist, in general, in a reduction of fever-temperatures, and, in particular, in an abatement of pains in fibrous tissues, notably the pain of affected parts in acute articular rheumatism; and in an occasionally seen abatement of the glycosuria in saccharine diabetes. The antipyretic power of salicylates is second to none, in all the three elements of quickness, degree, and duration of reduction of temperature. For a full antipyretic effect, however, considerable dosage is necessary—considerable enough to cause disagreeable sweating, *tinnitus aurium*, depression of pulse and respiration-rate, and, every now and then, actual toxic symptoms. The antirheumatic faculty of salicylates is unapproached by any other known medicine, so that, as is well known, salicylates constitute a standard set of medicines for the treatment of acute rheumatism. Various opinions have been held concerning the efficacy of salicylates to accomplish more in this disease than the obvious reduction of temperature and abatement of pain. Some maintain that these effects are all that can properly be ascribed to the medicine; while others consider statistics to show for salicylate treatment a shortening of the duration of the rheumatic attack and a lessening of the frequency of cardiac complications. The antidiabetic power of salicylates, as is the case with the same faculty shown by other medicines, is very variably manifest in different cases of glycosuria. Sometimes the effect is *nil*, while in other cases the sugar may, for a while at least, totally disappear from the urine as the direct result of salicylate treatment—the diet remaining as before during the period of the observation. For decided results full dosage is necessary, and full doses are often exceedingly well borne in diabetes, the subject hardly experiencing any obvious derangement from the medicine.

The salicylates in *common medical use* for the purpose of salicylate medication are the salicylates, respectively, of *sodium, lithium,* and *methyl*—the last named in the shape of the volatile *oil of gaultheria,* which consists of ninety per cent. of methyl salicylate. The salicylates, respectively, of *physostigmine, quinine,* and other alkaloids, are used for the sake of the medicinal action of the respective bases only.

Sodic Salicylate, $2NaC_7H_5O_3.H_2O$. The salt is official in the United States Pharmacopœia under the title *Sodii Salicylas,* Salicylate of Sodium. It is thus described: "Small, white, crystalline plates, or a crystalline powder, permanent in the air, odorless, having a sweetish, saline, and mildly alkaline taste, and a feebly acid reaction. Soluble in 1.5 parts of water, and in 6 parts of alcohol at 15° C. (59° F.); very soluble in boiling water and in boiling alcohol. When heated, the salt gives off inflammable vapors, and leaves an alkaline residue amounting to between thirty and thirty-one per cent. of the original weight, which effervesces with acids, and imparts to a non-luminous flame an intense yellow color, not appearing more than transiently red when observed through a blue glass. On supersaturating the aqueous solution with sulphuric acid, a bulky, white precipitate is obtained, which is soluble in boiling water, from which it crystallizes on cooling; also soluble in ether, and striking an intense violet color with ferric salts" (*U. S. Ph.*). Sodic salicylate is the most commonly used salicylate, and is a very important medicine. It is easily made *in solution* by mixing salicylic acid and a sodic carbonate in the presence of water, whereupon sodic salicylate results, and remains in solution, and carbon dioxide gas escapes in effervescence. From this solution the salt can be obtained by evaporation to dryness, carefully conducted. Extemporaneous preparation of the medicine *in solution* being easy, Squibb points out an advantage of such extemporaneous making of the salt in all cases where the prescriber or the dispenser may not be certain of the purity of the market article. The point is that the purity of a given sample of *sodic salicylate* is not easy of establishment except by an elaborate chemical analysis, whereas a good sample of *salicylic acid* is immediately recognizable by the simple fact of its *crystalline condition.* Hence, in making one's own sodic salicylate from a selected well-crystallized sample of salicylic acid, purity is assured. And in the instance of this salt purity is important, since, as above said, there is probably good reason to lay many of the untoward effects of salicylates to the door of the contaminating acid of salicylic acid. Squibb recommends the following formula for the preparation of a solution of sodic salicylate of a strength convenient for use as a medicine: "Take of salicylic acid, well crystallized, 437 grains = 28.32 grammes; bicarbonate of sodium, 270 grains = 17.5 grammes; water, free from iron, a sufficient quantity. Put the acid into a vessel of the capacity of a pint, add 4 fluidounces = 120 c.c. of water, stir well together, and then add the bicarbonate of sodium in portions with stirring, until the whole is added and the effervescence is finished. Filter the solution, and wash the filter through with water until the filtered solution measures 6 fluidounces, or 180 c.c. This solution contains 10 grains (= 0.65 grammes) of the medicinal salicylate of sodium in each fluidrachm (= 3.75 c.c.). If made from good materials, the solution before filtration is of a pale, amber color, but as most ordinary filtering paper contains traces of iron, the filtered solution is often of a deeper tint." The proportions of the ingredients for this solution are estimated so that the solution shall be neutral, but, "owing to the varying proportions of hygrometric moisture in the materials," the neutrality may not always be absolute. According to Squibb, a well-made sample of sodic salicylate, prepared by use of a well-crystallized sample of acid, is always, when evaporated to dryness, *white,* and is free from all *odor of carbolic acid,* unless it have been shut up for a long while in a bottle. Even then, however, the odor should be but very faint—only perceptible on close examination, and should disappear upon exposure of the sample to air. *Solutions* of sodic salicylate of good quality should have none of the carbolic acid smell.

Sodic salicylate is used almost exclusively as an internal medicine, being commonly held to be lacking in the germ-sterilizing faculty which gives salicylic acid, as such, its applicability as a local antiseptic. For the purposes of internal salicylate-medication, as set forth above, the salt is thoroughly effective, and, if made from a well crystallized and therefore fairly pure sample of salicylic acid, rarely produces untoward effects in reasonable doses. So large a quantity as 5.00 Gm. (about seventy-seven grains) has been given at a single dose in rheumatism without producing serious derangement, but the ordinary dosage for an antipyretic or antirheumatic effect does not exceed 1.30 Gm. (twenty grains) repeated every two hours, for three or four doses, or until a distinct impression is produced, followed by doses of half the quantity every hour or two thereafter, as long as the influence of the medicine may be required. In diabetes, doses of 1.30 Gm. (twenty grains) three or four times daily may be required, and can often be borne without derangement of the stomach or an unpleasant degree of ringing in the ears. The medicine is readily enough taken in simple aqueous solution, but if the faint, mawkish taste of the salt be objected to, the addition of twenty per cent. of glycerin and the flavoring with a drop or two of oil of gaultheria will render the mixture perfectly palatable.

Lithic Salicylate, $2LiC_7H_5O_3.H_2O$. The salt is official in the United States Pharmacopœia under the title *Lithii Salicylas,* Salicylate of Lithium. It is thus described: "A white powder, deliquescent on exposure to air, odorless, or nearly so, having a sweetish taste, and a faintly acid reaction. Very soluble in water and in alcohol. When strongly heated, the salt chars, emits inflammable vapors, and finally leaves a black residue having an alkaline reaction, and imparting a crimson color to a non-luminous flame. On supersaturating the dilute aqueous solution with hydrochloric acid, a bulky, white precipitate is obtained, which is soluble in boiling water, from which it crystallizes on cooling; also soluble in ether; and producing an intense violet color with ferric salts" (U. S. Ph.). The effects of this salt are similar to those of sodic salicylate, with the possible super-addition of medicinal virtues, in rheumatic or gouty cases, derived from the basic element. The dose is similar to that of the sodic salt.

Methylic Salicylate, as already said, is used only as it occurs as the main ingredient of the volatile oil of gaultheria. See Wintergreen. *Edward Curtis.*

SALIES-DE-BÉARN is situated in a well-protected valley in the Département des Basses-Pyrénées, France. There are several springs here, all strongly saline, the most important of which is the Source du Baillat. The following is the composition of this water, according to the analysis of Henry. One litre contains:

	Grammes.
Sodium chloride	216.020
Potassium chloride	2.080
Sodium sulphate, Magnesium sulphate, Calcium sulphate, Potassium sulphate	9.750
Magnesium and calcium bicarbonate, Ferrous oxide, organic matter	5.500
Silica and alumina	1.056
Total	234.406

There are traces also of iodine and bromine.

The waters are used externally and internally in the treatment of so-called scrofulous affections of the glands, bones, and articular structures, of subacute and chronic rheumatism, and of anæmia following hæmorrhage, or induced by long-continued suppuration. *T. L. S.*

SALINS is a small village in the Département du Jura, France, lying at an elevation of about a thousand feet above sea-level. The climate is subject to considerable changes of temperature, the days often being quite warm while the mornings and evenings are cool. There are

several mineral springs, the most important of which is known as the Puits à Muire (Grotto A). The following is the analysis made by Réveil. One litre contains:

	Grammes.
Sodium chloride	22.74516
Magnesium chloride	0.87013
Potassium chloride	0.25652
Potassium bromide	0.03065
Calcium sulphate	1.41667
Potassium sulphate	0.68080
Total	25.99993

There are traces also of sodium iodide and of calcium and magnesium carbonates.

When employed for bathing purposes this water is sometimes strengthened by the addition of a brine containing about 320 Gm. of saline constituents to the litre.

The waters are used internally and, in the form of baths, douches, and local compresses, externally. Like other waters of this group, they are employed chiefly in the treatment of rheumatic troubles, anæmia, and the so-called scrofulous affections. *T. L. S.*

SALIVATION. The term salivation is used to denote a superabundant secretion and flow of saliva. This use of the word has been objected to on the ground that salivation should properly signify a physiological act, in analogy, perhaps, with such words as urination, defecation, lactation, and the like. But the Latin word *salivatio* is derived from the transitive verb *salivo* (from *saliva*), which means to salivate, to produce an excessive flow of saliva. The synonym *ptyalism* would, perhaps, be less liable to ambiguous construction. The term *sialorrhœa*, while indicating an abnormal flow, does not necessarily imply abnormal secretion. It often happens that saliva accumulates in the mouth or drools from the lips, through failure in the act of deglutition, even when not produced in abnormal quantity. Thus in sleep, especially in certain conditions of debility, and when the head is in a dependent position, the saliva may escape from the mouth because the muscles or nerves of deglutition are inactive, as it does habitually from a similar cause in the case of imbeciles. Similarly, when, in consequence of inflammation of the throat, as in acute tonsillitis, the act of swallowing is instinctively avoided or rendered impossible through tumefaction of the parts, the saliva often appears to be in excess; but this is due rather to passive accumulation than to any excess of secretion from reflex irritation.

As to the exact amount of secretion necessary to constitute a superabundance, it is difficult to speak definitely. Normally, the quantity of the secretion varies from two to three pints in the twenty-four hours. In salivation it is often increased to from three to four pints, and may reach six or eight pints or more in the day. In the simplest cases it may only be sufficient to cause moderate discomfort from the frequent necessity of swallowing or spitting; in the most aggravated cases, on the other hand, salivation becomes a fatal malady, partly through the prolonged and excessive drain upon the economy by the loss of the solids contained in the salivary discharge, and partly through the intensity of the concomitant stomatitis and the interference with nutrition consequent upon the inability to swallow the necessary food.

In addition to the increase in quantity, there is also more or less alteration in the character of the secretion. The proportion of water may be either increased or diminished—the latter more particularly in inflammatory conditions, when the solid ingredients are augmented. The saliva is then cloudy in appearance, and often contains gray or blackish flocculi. In certain nervous forms of salivation albumen may be present in the secretion. The ptyaline is usually diminished in quantity. The reaction is commonly neutral or alkaline, and but rarely acid; in the latter case the acidity is said to be due to the buccal mucus. In cases accompanied with stomatitis the salivation is attended with a fetid and characteristic odor.

The association of stomatitis with salivation, while very common, is by no means necessary. Very often the buccal inflammation is the primary and more essential disease, the ptyalism being secondary to it and the result of irritation reflected from the mucous membrane of the mouth to the salivary glands. In other cases both the ptyalism and the stomatitis are more or less the direct effects of a common cause. But there is no evidence that ptyalism, as such, can be the cause of stomatitis.

A very common cause of salivation is a reflex irritation of the glands, which has its starting-point in the buccal mucous membrane. The irritation is conveyed by the centripetal nerves to the medulla, and thence transmitted through the secretory filaments of the chorda tympani to the salivary glands. This irritation may be excited by the so-called "topical" sialagogues—strong acids and alkalies, ethereal substances and the various masticatories, such as pyrethrum, horseradish, ginger, mezereon, tobacco, cubebs, and the like. Again, the irritation may proceed from the teeth, as in dentition or dental caries. Erythematous stomatitis, aphthæ, buccal ulceration, ulcero-membranous stomatitis, gangrene, and cancer of the mouth are likewise all attended with salivation in greater or less degree. In the mercurial and scorbutic forms of salivation, gingivitis or more extensive inflammation is an almost invariable accompaniment, and the latter commonly precedes the ptyalism. In many of these cases, however, when the flux first appears, the swelling and redness of the mucous membrane are concealed by thickening and opacity of the epithelium, so that the presence of the stomatitis might easily be overlooked. So far as the scorbutic form is concerned, the sialorrhœa is doubtless dependent solely upon the buccal inflammation.

Again, irritation may be transmitted to the salivary glands in a similar manner from regions more remote than the mouth. Nausea is commonly attended with abnormal flow of saliva, as are various forms of disease of the stomach, or even the presence of food, the irritation being communicated to the medulla through the vagus and thence to the salivary glands. Frerichs found that the saliva was secreted abundantly so soon as food was introduced into the stomach through a gastric fistula. It is said also that irritation of the splanchnic nerve, whether by means of an electric current or through intestinal disease,. may produce salivation. Ptyalism may be associated with the presence of intestinal worms.

The salivation that sometimes occurs as a symptom of pregnancy has been attributed directly to irritation of the uterine nerves, but not improbably it is the nausea that usually attends this condition, and the consequent irritation of the pneumogastric, which is the more direct cause of the ptyalism. According to Dewees, in all pregnant women there is more or less excess in the secretion of saliva. When the salivation is marked the salivary glands are usually swollen and tender, and there is a certain degree of swelling and congestion of the buccal mucous membrane. The gums, however, do not become sore, spongy, or ulcerated, and there is no fetor from the mouth. The amount of saliva secreted varies, but may reach as high as three or four quarts in the twenty-four hours (Tanner). The affection generally begins at an early period of gestation, coincidently with the period of the so-called "morning sickness," disappearing generally by the end of the third month; though it may persist during the entire course of pregnancy, and, in some rare instances, for one or two months after parturition. It is stated that menstrual troubles also may give rise to ptyalism.

A "nervous" form of salivation may be the result either of transitory impressions on the sensorium or of neuropathic conditions of the nerves or nerve-centres. Of the former a common example is the so-called "watering of the mouth," at the sight or suggestion of certain kinds of food. "Frothing" of the mouth, another form of sialorrhœa, may be the result of mental emotion. Mental disease (acute mania, melancholia, hypochondria) may also be accompanied with ptyalism. The same affection may occur as a symptom of facial neuralgia, or of disease of the medulla, brain, or spinal cord. It is observed in connection with certain forms of partial or general paralysis, and with progressive muscular atrophy;

also in hystero-epilepsy and in rabies. In some of these cases it is possible that a condition of atony of the submaxillary ganglion may account for the salivation. According to Claude Bernard, this ganglion has a moderating or inhibiting action upon the secretory function of the salivary glands, and when its influence is withdrawn, the secretory filaments of the chorda are free to act without restraint.

Sometimes salivation, occurring in connection with certain fevers, has the character of a "critical" flux. It has been observed in pneumonia, typhoid fever, dysentery, and other acute febrile diseases. This form, however, is rare.

It remains to speak of the ptyalism that is the result of the systemic or toxic action of certain medicaments. These, in contradistinction to the sialagogues that owe their effect solely to topical irritation of the buccal mucous membrane, are known as "general" or "remote" sialagogues. Such are jaborandi, physostigma, muscarin (obtained from bitter orange), tobacco, mercury and its compounds, the compounds of iodine, gold, and copper, and also the so-called nauseants. The last-named doubtless produce this effect upon the salivary glands reflexly, through the gastric division of the vagus. With regard to the others, the mode of action has been too little studied to justify positive conclusions. It is quite possible that in some instances the effect is due to a toxic irritation of the medulla, whence the stimulus is conveyed to the salivary glands through the chorda tympani. Many of these drugs are eliminated with the saliva, and in some this elimination is attended with stomatitis. In the latter case the ptyalism may be secondary to the buccal affection. Jaborandi, which salivates within half an hour, and sometimes by the end of two minutes, causes no inflammation of the mucous membrane of the mouth, and doubtless acts directly upon the salivary glands. That it does not act through the nerves has been demonstrated by experiment. Salivation occurs after injecting pilocarpine into the blood, even when the nerves supplying the salivary glands have been previously divided. The same is said to be true of muscarin, physostigmine, and nicotine. Gold does not cause stomatitis, it is said, and it probably acts in a similar manner to the above. On the other hand, the salivation from mercury and copper is almost invariably accompanied with more or less inflammation of the mouth.

Of all forms of salivation, the one most frequently observed is that which occurs as a toxic manifestation of the constitutional action of mercury. That the stomatitis, which so commonly attends this form, plays a very important part in the etiology of the ptyalism, does not admit of doubt. As to the question whether it is the sole cause of the latter—whether without the stomatitis there would be no ptyalism, a number of well-authenticated cases, in which salivation occurred without any signs whatever of buccal inflammation, give a pretty definite answer. Hallopeau mentions a case observed by Fournier, in which salivation was produced by mercurial inunctions without the gums showing the least trace of inflammation. Similar cases have been observed by Fournier and others. Von Mering several times saw salivation produced in cats in five minutes after a hypodermic mercurial injection.

The opinion has been held that mercurial salivation is a dynamic effect of the mercury acting upon the general system, while others have maintained that it was due to an impression produced upon the sympathetic ganglia. The most rational explanation, however, is that it is the direct effect of the mercury contained in, and eliminated by, the saliva. That mercury is eliminated by the saliva there can no longer be any room for doubt. It has been verified repeatedly, and Bernatski has even succeeded in finding the metal in the saliva coming directly from Steno's duct. Doubtless both the ptyalism and the stomatitis may be due to the same irritating cause contained in the saliva, although the former would naturally be aggravated by the existence of the latter. All the facts seem to point to the presence of a corrosive poison in the secretion.

According to Ricord, the starting-point of this form of stomatitis is an area of inflammation just behind the last molar tooth, on the side on which the patient habitually sleeps, and this observation has also been repeatedly verified by Fournier. The natural inference is that the trouble begins where the saliva collects, and where the poison would therefore become concentrated. The well-known influence of the teeth in the production of mercurial gingivitis has an important bearing here. Edentulous individuals, such as infants and toothless old men, do not have inflammation of the gums when mercurialized. It would seem, therefore, that it is the collection and concentration of the poisoned saliva about the teeth that excites inflammation in the gums. It is a noteworthy fact, true as well of those who are exposed to the action of mercury by the nature of their occupation as of those who take it medicinally, that when particular attention is paid to the teeth, when they are often and carefully brushed, the individual most frequently escapes mercurial stomatitis. Indeed, it is a matter of every-day experience that patients undergoing mercurial treatment who are careful to keep the teeth clean, rarely show any oral effects whatever. Hutchinson says,[1] with regard to the so-called "mercurial teeth," that "the effects produced by mercury concern chiefly the enamel, although when severe, they affect the dentine also. The enamel is usually deficient, and the surface of the teeth is in varying degrees rugged, pitted, and dirty. The incisors and canines are usually affected, and not infrequently we see the enamel deficient on them all, below a line which crosses them at the same level. The appearance produced is much as if a line had been stretched horizontally across these teeth at about their middle." "The first molars" are "almost invariably affected" also. These appearances point pretty clearly to a corrosive effect, to which the teeth were subjected at an early age through the administration of mercury. The "line" of defective enamel mentioned corresponded, doubtless, in early childhood to the line of the gums, and to the part where the secretions and impurities of the mouth would be most apt to collect. Furthermore, it should be noted that of all modes of administration, that which brings the mercurial in direct contact with the mouth is most likely to cause stomatitis. Overbeck attributed the peculiar liability of calomel to produce salivation to the fact that, of all preparations, it was most apt to leave traces of the dose in the buccal cavity, where it would act topically after solution in the salivary fluid. In this connection we recall the observation of John Hunter, that every mercurial, when held long in the mouth, becomes sapid, showing that a solution takes place.

The inference seems unavoidable that the mercurial stomatitis, and to a certain extent also the ptyalism, are due to the elimination of the mercurial, which becomes corrosive immediately upon its escape from its organic connections. While circulating in the fluids of the body it is in intimate combination with the albumen, forming an albuminoid compound which almost assumes the character of the homogeneous substances of the body. But at the moment of elimination a noxious inorganic chemical substance is set free to work its deleterious effects. To account for the severity of these effects it must be remembered that there is a continual irrigation of the parts with the solution, and not a single application. And, furthermore, this solution will become more concentrated where the secretions are apt to collect, *i.e.*, at the borders of the teeth.

Of the conditions which are favorable to mercurial salivation, the most important depend upon the mode in which the mercury is introduced into the system. Generally speaking, those methods by which the drug is most rapidly introduced and absorbed are most likely to cause salivation. It is stated that it is oftenest observed after inunctions, fumigations, and the administration of calomel. It has been erroneously claimed that it was comparatively infrequent among workers in mercury. But, according to Kussmaul, though seldom so severe among them as when the drug is given therapeutically, it is

nevertheless always the most common of the symptoms of hydrargyrism. In the professional form of mercurialism the amount of mercury received into the economy is much smaller than when it is administered as a drug, and it is introduced more gradually. Hence acute toxic manifestations, such as ptyalism and stomatitis, are not often severe, while the constitutional disturbances are commonly more marked than in patients who are mercurialized therapeutically.

The dose necessary to produce mercurial salivation varies according to individual predisposition. Some individuals are singularly susceptible. Ricord speaks of a patient in whom one grain of calomel was sufficient to cause salivation. Trousseau saw a violent case follow a single vaginal injection of a solution of corrosive sublimate 3 parts in 5,000 parts of warm water. Breschet observed a similar effect in a woman the morning after the vaginal portion of the cervix had been cauterized with the acid nitrate of mercury. Gubler saw severe stomatitis result from a single mercurial friction to the abdomen of a woman suffering with puerperal peritonitis. Christison reported cases in which salivation followed, in one instance the administration of two grains of calomel, and in another the inunction of two drachms of mercurial ointment. On the other hand, cases are met with where prolonged exhibition of mercury in considerable doses fails to produce the slightest effect in the mouth. Hallopeau refers to a case in which a patient, who had been treated for months with mercurial inunctions without salivation, afterward had a stomatitis in consequence of a single local application of mercurial ointment for pediculi pubis. As a rule, women are more susceptible than men, and pregnant women are especially liable to it. Exposure to cold, when the system is under the influence of mercury, will often provoke or precipitate an attack of salivation. The influence of disease of, or neglect in cleansing, the teeth has already been referred to. The fact that a patient has previously been salivated appears to render the person more susceptible to a subsequent attack, perhaps for the reason that a certain amount of mercury still lingers in the system. Under certain provocations this residual mercury may give rise to ptyalism long after the use of mercury has been stopped. Kussmaul cites the case of a woman who had a sudden attack of salivation, without stomatitis, in connection with a severe frontal headache. The woman was pregnant, and her condition may have had something to do with the causation of the salivary flux; but it was discovered that at this time both the saliva and the urine contained mercury, though it was known that shortly before the attack the drug was not present. The patient had been a worker in quicksilver four years before, and had suffered severely during her employment from mercurialism with stomatitis. Other observers also have testified to the fact that salivation may occur at long intervals after exposure to mercury, whether professionally or medicinally; sometimes after exposure to cold; occasionally after the administration of certain drugs (especially the iodide of potassium), in connection with commencing gestation or with some nervous affection.

Thanks to the more conservative and rational treatment of syphilis now generally pursued, mercurial salivation is far from being the common malady it was in former times. Instead of being regarded as a necessary accompaniment of the cure in every case of syphilis, it has now, among the best practitioners, become an accident of exceptional occurrence. How important was the rôle that salivation formerly played in the treatment of syphilis appears from the following aphorisms of Boerhaave:

"1468. To procure it, drench the patients for several days with large quantities of ptisan.

"1469. Next give a small dose of calomel every two hours.

"1470. When the breath begins to be fetid, the gums are painful, the teeth seem to grow longer, examine whether it be proper to continue, to stop, or to check the symptoms.

"1471. A salivation of three or four pounds a day is enough.

"1472. If less, it must be excited by mercury.

"1473. If more abundant, it must be restrained by emollient clysters, purges, sudorifics.

"1476. This treatment should be kept up till the symptoms have entirely ceased, usually thirty-six days.

"1477. Afterward, for thirty-six days more, give only very moderate doses of mercury, to maintain a slight salivation."

When a patient is about to be salivated with mercury the first thing noticed usually is a sense of dryness and a disagreeable metallic taste in the mouth. If the teeth are clashed together the patient is aware of a little tenderness. The gums have a grayish appearance, or are slightly reddened and swollen, and if pressed upon a little pus wells up between their border and the teeth. There is emitted from the mouth a more or less fetid odor. Soon the gums begin to recede from the teeth, and when the tongue touches the latter it seems to the patient as though they were elongated. The tenderness increases and is accompanied with some pain in the jaws. Meantime the saliva increases in quantity, collects in the mouth, and, because of its disagreeable taste, the patient is often impelled to spit. The inflammation increases and extends to the lips, cheeks, and tongue. Their surfaces are covered with a whitish or yellowish coating, and exhibit the prints of the teeth. The saliva becomes more copious, and, if the case is severe, dribbles from the mouth. The mucous membrane becomes ulcerated, and the ulcers are covered with pseudo-membrane. The ulceration extends superficially rather than in depth. The teeth become loose. The mouth is kept continually open, with the swollen tongue protruding, and over the lips and chin flows a constant stream of stringy saliva, sometimes tinged with blood. The quantity may become enormous. The stench becomes horrible, tainting the air of the whole apartment in which the patient is. The condition of the patient, if the malady is not arrested, grows more and more distressing. The teeth drop out; the swelling and pain, which may extend to the face and neck, continue to augment till the patient can neither masticate nor swallow; speech becomes impossible, and even respiration may be greatly impaired. Sometimes deep gangrenous ulcers form and the mucous membrane separates in large sloughs. Occasionally there is suppuration of the parotid or cervical glands; sometimes phlegmon of the cheeks or roof of the mouth occurs, or there is gangrenous inflammation of the tongue; finally cicatricial deformities may result, unless the patient, worn out by the intensity of the disease and the impairment of nutrition, sinks into a fatal collapse. Cases of such intensity as this are fortunately very rare. The recovery in most severe cases is slow. The swelling gradually diminishes, the ulcers slowly heal, and the teeth regain their solidity. For a long time, however, the mucous membrane of the mouth remains vulnerable, and slight irritations, such as may arise from the use of sharp or pungent articles of food and the like, will suffice to reawaken the stomatitis and produce again some degree of sialorrhœa with more or less fetor of the breath.

The first indication for treatment in all cases of salivation is to remove, if possible, the offending cause. If the ptyalism be the result of a reflex irritation originating in the buccal cavity, in the stomach, or in regions still more remote, the surest way to relieve the secondary affection is to allay the primary irritation. Where this is impracticable, as, for example, in pregnancy, we may avail ourselves of certain drugs, such as belladonna or duboisia, which have a controlling influence over the salivary secretion. In other cases the offending cause is located in the salivary glands or contained in the saliva. In salivation from mercury the ptyalism is doubtless partly due to the direct action of a corrosive mercurial upon the salivary glands, but chiefly to the stomatitis which is the effect of the same corrosive poison in the mouth.

As already intimated, mercurial salivation is at the present time regarded as an exceptional occurrence in the treatment of syphilis, and is usually the result either of neglect of proper precautions, or of an idiosyncrasy on the part of the patient. If the mercury is judiciously

administered, the teeth properly attended to, and exposure to sudden changes of temperature avoided, the patient will rarely complain of ptyalism or stomatitis, except in their incipient stages.

So soon as signs appear indicating that the gums are "touched," the mercury should be suspended. Unfortunately there are cases in which this does not suffice to arrest the progress of the malady. The mercury accumulated in the system continues for some time to be eliminated in the saliva in sufficient quantity to maintain or augment the local irritation. Therefore, when the latter does not quickly subside, measures should be taken both to hasten elimination and to divert it to other emunctory channels. At the beginning, a brisk purge is to be given, followed by a series of hot baths and the administration of diuretics. To the same end iodine or the iodide of potassium may be given, bearing in mind, however, that the first effect of these remedies, sometimes, is to aggravate the trouble, though they are afterward beneficial in limiting its duration. The use of iodine to arrest salivation was first recommended by Knod. It is given in doses of ten centigrammes (one and a half grain) per day, gradually increased to twice that amount, as in the following formula:

℞. Iodine .... 0.25 (gr. iijss.).
Alcohol .... 8.00 (ʒ ij.).
Dissolve and add cinnamon
water .... 80.00 (℥ ijss.).
Simple syrup .... 16.00 (ʒ ij.).
M. Dose, two to four teaspoonfuls.

To check the flow of saliva one one-hundredth of a grain of atropia may be injected hypodermically, and repeated according to the effect. The inflammation of the mouth must be combated by astringent or disinfectant washes, and by the local and internal use of the chlorate of potash. Mouth-washes of borax, alum, or tannin in honey or glycerine and water (seven or eight grains to the ounce), or tincture of myrrh (ʒ ij.–iv.) in water or infusion of cinchona (℥ iv.), serve a good purpose. The chlorate of potash may be used as a mouth-wash, dissolved in cold tea or in infusion of flaxseed, to which a small portion of dilute hydrocyanic acid or spirits of chloroform may be added. It should also be administered internally in doses of two or three grains every hour or two. Should ulceration or gangrene supervene, mouth-washes containing carbolic acid, Labarraque's solution, or the permanganate of potash are required.

Edward Bennet Bronson.

[1] Illustrations of Clinical Surgery, p. 54. London, 1878.

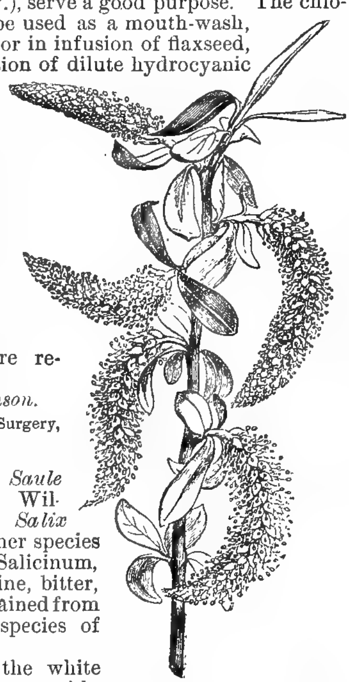

Fig. 3363.—Salix Alba, Staminate Branch. (Baillon.)

SALIX (U. S. Ph., *Saule blanc*, Codex Med.). Willow; "The bark of *Salix alba* Linn. and of other species of *Salix*." Salicin (Salicinum, U. S. Ph.), a crystalline, bitter, neutral substance, obtained from the bark of various species of Salix.

Salix alba Linn., the white willow, is a large tree with, when old, often a very thick, irregular trunk, dividing near the ground into several great limbs; branches numerous, ascending, rather close; twigs slender, brittle, with a light yellow or yellow-green bark, and white, rather brittle, soft wood; young shoots, buds, and the under surface of the leaves silky; leaves numerous, alternate, with minute stipules and short petioles; blade lanceolate, narrow, and very acute at the apex, white beneath, border finely serrate; flowers early, diœcious, in slender, weak spikes, each flower in the axil of a small bract; staminate flowers consist of two stamens, the pistillate of one one-celled, many-ovuled ovary; fruit dehiscent; two-valved, seeds silky. This willow has a very wide natural range, covering most of the temperate belt of the Old World; it has been also introduced into North America, where it is firmly naturalized. The bark of the small branches is officinal, and is collected with that of some other willows of similar appearance and properties.

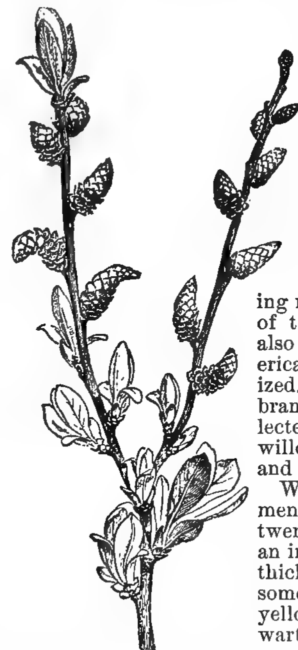

Fig. 3364.—Salix Alba, Pistillate Branch. (Baillon.)

Willow bark is "in fragments or quills, from one-twenty-fifth to one-twelfth of an inch (one to two millimetres) thick, smooth; outer surface somewhat glossy, brownish or yellowish, more or less finely warty; under the corky layer green; inner surface brownish-white, smooth, the fibres separating in thin layers; inodorous; bitter, and astringent." Willow is an old tonic and febrifuge, formerly official abroad, but dropped from most pharmacopœias since the easy preparation of salicin, which in a great measure took its place; neither is much used at present.

Fig. 3365.—Salix Alba, Fruit. (Baillon.)

Composition.—The bitter, crystalline, neutral principle, *salicin*, is the characteristic derivative of all the willows. It is easily prepared by exhausting the bark with water, precipitating tannin, etc., with litharge, evaporating and crystallizing out the salicin, which is then purified by resolution and the same process again. Salicin is colorless, odorless, but very bitter; it crystallizes in scales and needles; is permanent in the air; melts at 198° C. (388.4° F.); dissolves in twenty-eight parts of water and thirty of alcohol; sublimes and is entirely dissipated by heat; with concentrated sulphuric acid it forms a red solution. It is a glucoside; treated with diluted sulphuric or hydrochloric acid, or with a powerful galvanic current, it is decomposed, and saligenin and glucose are formed; by other methods of handling many interesting derivatives have been obtained; salicylous and salicylic acids, saliretin, helicin, helicoidin, etc. It has also been formed synthetically.

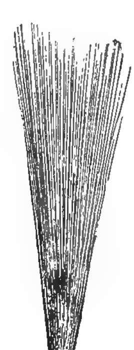

Fig. 3366.—Salix Alba, Seed. (Baillon.)

Action and Use.—As salicin is the only active principle, whatever value this bark has is due to it. Salicin itself, it must be confessed, is far from an energetic remedy—between two and three ounces have been taken with no marked effect. It appears to be decomposed in the blood into saligenine, salicylic acid, etc., and is eliminated from the kidneys as one or more of these products. Salicin has undoubted antipyretic power, although less than quinine or salicylic acid, its antiperiodic action is much less than

that of either of them; as a remedy in rheumatism, salicin has also been obliged to yield to the more useful salicylic acid. As a tonic, in small doses, it is occasionally used, but is far inferior to gentian or quinine. Four or five grams (ʒ j. ad ʒ jss.) may be given as a dose, and repeated every three hours; as a tonic one or two decigrams (gr. jss. ad iij.) is sufficient.

Allied Plants.—The genus comprises a hundred and sixty species; from twenty or more this substance has been obtained. The allied genus *Populus* has some salicin-yielding species, and others containing *populin*, which latter can be made to yield salicin itself by decomposition. The order, in its narrow sense, contains but these two genera.

Allied Drugs.—A number of plants in different orders yield also a little salicin, but not enough to make it their characteristic principle. The various tonics, of which Gentian, Columbo, Cinchona, etc., are examples, are also related, and the latter is doubly so as an antiperiodic. Other glucosides of mild or tonic qualities are *hesperidin*, from orange peel; *phloridzin*, from apple bark; *arbutin*, from several *Ericaceæ; æsculin*, from the horse-chestnuts, etc.

W. P. Bolles.

SALOL. Under the titles *salol* and *salicylate of phenol*, there has been recently proposed, for medicinal use, a body compounded of salicylic acid and carbolic acid (phenol), representing in its composition sixty per cent. of salicylic acid and forty per cent. of carbolic. Salol is a white crystalline powder, melting at 43° C. (110° F.) into a colorless, oily fluid. It is nearly insoluble in water, but dissolves in alcohol, ether, and fixed oils. From its insolubility in aqueous fluids it is practically tasteless in powder, but it has a faint aromatic smell.

Salol has been proposed as a substitute for the commonly used salicylate salts, on the grounds that it is equally, at least, effective as a medicine, while at the same time, in medicinal doses, it is much less deranging to digestion on the one hand, and less productive of constitutional toxic effects on the other. It is said of this substance that it is insoluble in the fluids present in the stomach—whence the lack of gastric derangement in its employment—but suffers solution by chemical decomposition in the small intestine through the action of the pancreatic juice, resolving into salicylic acid and carbolic acid (phenol). Constitutionally, so far as reported, salol, in ordinary dosage, has produced little disturbance beyond an occasional and trifling ringing in the ears. In experimenting, however, with a dosage exceeding 6.00 Gm. (about a drachm and a half) distributed over the twenty-four hours, toxic symptoms have been observed. Salol, taken internally, imparts to the urine of the subject the peculiar coloration seen after ingestion of carbolic acid, a phenomenon that may persist for several days after discontinuance of the medicine. The average medicinal dose of salol for an antirheumatic or antipyretic effect is 2.00 Gm. (about thirty grains), given twice, or possibly thrice, daily. A dosage reaching 8.00 Gm. (about two drachms), in the course of a day, was followed, in one instance, by severe vomiting, gastralgia, and tinnitus. Salol may be taken dry upon the tongue, in powder, the dose to be washed down with a little water, or may be conveniently administered in pill-form.

Edward Curtis.

SALT SULPHUR SPRINGS. *Location and Post-office*, Salt Sulphur Springs, Monroe County, W. Va.

Access.—By the Chesapeake & Ohio Railway to Fort Spring, two hundred and forty-four miles west from Richmond, Va., thence by stage fifteen miles south to the springs. Stages meet the C. & O. Railway trains at Fort Spring.

Therapeutic Properties.—The name Salt Sulphur would imply the presence of an appreciable amount of sodium chloride. This is not the case, so that the name is not appropriate. They are rather alkaline sulphur waters, purgative and alterative. Taken internally or employed as baths, they are effective in chronic diseases of the digestive organs, bladder, liver, and kidneys, and I am informed of their utility in chronic neuralgias. The iodine spring is indicated in syphilitic and scrofulous disorders.

Analysis.—One pint contains:

	Old Spring, 49° F. to 56° F. Prof. W. B. Rogers.	Iodine Spring, 56½° F. D. Stewart. M.D.
	Grains.	Grains.
Carbonate of potassa	......	0.291
Carbonate of soda	......	1.350
Carbonate of magnesia	0.414	0.875
Carbonate of lime	1.283	4.125
Chloride of sodium	0.197	0.188
Chloride of magnesium	0.033	0.035
Chloride of calcium	0.007	0.070
Sulphate of soda	2.795	3.000
Sulphate of magnesia	2.276	2.500
Sulphate of lime	10.613	8.500
Peroxide of iron	0.012	0.133
Iodine	trace.	0.079
Bromine	......	0.081
Silicic acid	......	0.220
Alumina	......	0.023
Earthy phosphates (soda and lithia)	trace.	0.091
Organic matter (with sulphur)	1.155	.....
Total	18.785	21.561
Gases.	Cub. in.	Cub. in.
Carbonic acid	1.66	4.32
Sulphuretted hydrogen	0.43	2.39

This resort, possessing the Iodine, Salt Sulphur, and Sweet Sulphur Springs, is beautifully situated in a valley north of Peter's Mountains, Alleghany range, on the banks of Indian Creek, at an elevation of 2,000 feet above sea-level. The surrounding views of mountains and hills are charming, and the climate is delightful. The hotel buildings are built principally of brick and stone, the largest containing seventy-two rooms, with wide piazzas, and surrounded by a beautiful lawn. An elegant ballroom, a billiard-room, tennis courts, bowling alleys, etc., furnish amusement for the guests.

G. B. F.

SALZUNGEN is a spa in Sachsen-Meiningen, Thüringen, lying in the valley of the Werra, at an altitude of about 820 feet above the level of the sea. There are several salt-wells here, the composition of one of which, the Bernhardsbrunnen, is as follows.

One litre contains:

	Grammes.
Sodium chloride	260.76419
Potassium chloride	0.32566
Magnesium chloride	0.20179
Calcium chloride	0.78266
Magnesium bromide	0 01218
Sodium sulphate	1.25679
Calcium sulphate	3.34013
Magnesium sulphate	0.19408
Calcium carbonate	0.05199
Magnesium carbonate	0.00188
Ferrous carbonate	0.01318
Silicic acid	0.00259
Total	266.94712

There are also traces of iodine, lithium, aluminium, and manganese. There is some carbonic acid gas. When employed internally, the water is usually diluted with milk or whey. Baths, douches, local compresses, and inhalations are made use of.

These waters are employed in the treatment of catarrhal troubles of the respiratory mucous membranes, anæmia, and scrofulous affections of the joints, bones, glands, and skin.

The season extends from the middle of May to October. A course of treatment lasts from two to three weeks.

T. L. S.

SAN ANTONIO. The accompanying chart, obtained from the Chief Signal Office, represents the climate of the city of San Antonio, Tex., a town of twenty thousand inhabitants, lying at an elevation of six hundred and fifty-six feet above sea-level, and situated two hundred and forty-five miles to the north of Brownsville, and one hundred and thirty miles from the coast of the Gulf of Mexico. Its climate may be regarded as typical of that of the inland and moderately elevated portion of Southern

Climate of San Antonio, Tex.—Latitude 29° 28′; *Longitude* 98° 22′.—*Period of Observations, March* 1, 1877, *to June* 15, 1883.—*Elevation of Place of Observation above the Sea-level,* 656 *feet.*

	A. Mean temperature of months at the hours of			AA. Average mean temperature deduced from Column A.	B. Mean temperature for period of observation.	
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.
January	45.4	58.8	51.3	51.8	61.2	43.4
February	48.8	63.1	55.2	55.7	60.7	53.0
March	57.1	72.3	63.3	64.2	70.2	60.7
April	63.1	79.0	68.8	70.3	71.2	68.4
May	69.6	84.4	74.5	76.1	79.9	73.5
June	75.6	90.2	80.6	82.1	84.5	79.8
July	76.4	91.7	82.5	83.5	87.3	81.6
August	75.2	90.6	80.9	82.2	85.0	78.7
September	70.3	86.6	75.9	77.6	80.3	74.4
October	63.6	79.3	68.8	70.5	72.7	65.1
November	51.8	66.2	56.7	58.2	65.4	48.6
December	47.4	61.2	52.8	53.8	59.0	49.0
Spring	......	......	......	70.2	73.8	68.8
Summer	......	......	......	82.6	84.3	81.2
Autumn	......	......	......	68.7	71.7	63.2
Winter	......	......	......	53.7	58.8	49.4
Year	......	......	......	68.8	71.2	67.4

	C. Average maximum temperature for period.	D. Average minimum temperature for period.	E. Absolute maximum temperature for period.		F. Absolute minimum temperature for period.		G. Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	H. Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January	61.4	41.1	80.0	75.0	38.0	14.0	26	27
February	66.0	44.9	88.0	77.0	36.0	17.0	18	20
March	75.3	53.8	92.0	83.0	41.0	27.0	18	26
April	82.0	59.5	96.0	87.0	47.0	36.0	15	20
May	87.1	66.5	104.0	93.0	61.0	49.0	22	24
June	92.4	73.0	103.0	97.0	68.0	53.0	14	28
July	95.7	73.7	104.0	98.0	71.0	58.0	19	24
August	93.4	72.2	108.0	95.0	69.0	60.0	20	28
September	89.2	67.7	100.0	93.0	59.0	53.0	22	22
October	81.3	60.8	99.0	87.0	46.0	41.0	[illegible]	21
November	68.7	47.9	88.0	78.0	32.0	21.0	25	23
December	64.0	43.4	82.0	75.0	32.0	10.0	23	23
Spring	......	......	......	......	......	......	......	......
Summer	......	......	......	......	......	......	......	......
Autumn	......	......	......	......	......	......	......	......
Winter	......	......	......	......	......	......	......	......
Year	......	......	......	......	......	......	......	......

	J. Range of temperature for period.	K. Mean relative humidity.	L. Average number of fair days.	M. Average number of clear days.	N. Average number of fair and clear days.	O. Average rainfall in inches.	R. Prevailing direction of wind.	S. Average velocity of wind in miles per hour.
							From	
January	66.0	72.3	8.2	10.0	18.2	1.50	N.	4.8
February	71.0	67.6	6.2	9.8	16.0	1.86	N.	5.6
March	65.0	66.0	11.0	10.4	21.4	2.18	S.E.	4.9
April	60.0	64.0	11.0	9.3	20.3	2.87	S.E.	4.9
May	55.0	68.8	15.2	6.1	21.3	3.25	S.E.	4.8
June	50.0	68.3	18.8	6.5	25.3	2.14	S.E.	4.8
July	46.0	62.6	13.9	9.8	23.7	3.28	S.E.	4.6
August	48.0	67.0	17.7	8.2	25.9	3.67	S.E.	3.8
September	47.0	69.0	12.4	11.3	23.7	5.05	S.E.	4.2
October	58.0	69.7	10.2	12.5	22.7	2.78	S.E.	4.2
November	67.0	69.3	11.0	10.0	21.0	1.93	N.	4.9
December	72.0	69.5	9.5	9.5	19.0	2.04	N.	4.8
Spring	77.0	66.3	37.2	25.8	63.0	8.30	S.E.	4.9
Summer	55.0	66.0	50.4	24.5	74.9	9.09	S.E.	4.3
Autumn	79.0	69.3	33.6	33.8	67.4	9.76	S.E.	4 4
Winter	78.0	69.8	23.9	29.3	53.2	5.40	N.	5.1
Year	98.0	67.8	145.1	113.4	258.5	32.55	S.E.	4.7

Texas. What this climate is may be seen fairly well from a study of the chart (an explanation of which will be found on pages 189–191 of vol. ii.). The reader's attention is especially called to the general mildness of temperature during the winter season, which, *so far as shown by the figures of Column AA,* is seen to be nearly as warm as the autumn at New York City. Columns E, F, and J show, however, a great range of possible extremes at San Antonio, and Table F, in the article entitled Colorado Springs (vol. ii., p. 238), shows that the average daily range of temperature is thirty-three per cent. higher at San Antonio than at New York City. As a rule the atmosphere is remarkably still at San Antonio, and in this respect this station even surpasses that of Little Rock, Ark.; but San Antonio is a Texan town, and Texas, with its ill-famed "northers," is that part of the United States which is most liable to great and very sudden falls of temperature upon the supervention in winter of a northerly wind. Column K shows us that the San Antonio climate is moderately dry; column O, that the winter rainfall is very light. *H. R.*

SANDAL WOOD, OIL OF (*Oleum Santali,* U. S. Ph.; Br. Ph.; *Santal citrin,* Codex Med.; yellow (or white) sandal wood).

Santalum album Linn., order Santalaceæ, is a small East Indian tree, whose fragrant wood has made it a highly esteemed plant from the most remote time. It has a slender habit, with opposite branches, and smooth, light-green, opposite, lanceolate leaves; inflorescence small, close, pyramidal, paniculate cymes; flowers minute, perfect; the perianth is single, bell-shaped, four- or five-lobed, at first yellow, afterward purplish; stamens opposite, arising from the throat of the corolla, and separated by a series of alternate scales; pistil one, ovary one-celled, with central placentæ and three or four naked, pendulous ovules; fruit one-seeded, about as large as a currant. This tree is a native of India, and of some of the islands of the Indian Archipelago. It is also cultivated, the property of the government or protected by the authorities, in most localities; in others it has been exterminated.

Collection.—The logs are felled, cut into short lengths, and then left on the ground for several months, while the white ants gnaw away the alburnum, or white outside zone, and leave the valuable heart-wood perfectly cleaned. This is then cut and made into various articles of cabinet work or convenience, the chips and coarser portions being put into the still for the extraction of the oil. A considerable amount of the wood is exported to England and Germany, where a high grade of oil is distilled. The root is also dug up and used.

This is a compact, heavy, porous wood, of pleasant aromatic odor, pungent, astringent taste, and yellowish-brown, variegated color. The oi , of which it contains from one to three per cent., is a thickish, pale yellow liquid of agreeable, aromatic odor, pungent, spicy taste, neutral reaction, and specific gravity of 0.945.

As a perfume, etc., but not generally as a medicine, sandal wood has been used for more than a thousand years. It was known in Europe some eight hundred years ago, and it has always been a costly perfume. Its modern employment in gonorrhœa, etc., is not more than a generation old.

Of the different trade varieties, that from the East Indies is most highly prized, that of the West Indies and South America the least. There may not be so very much difference in their medical properties.

Action and Use.—Sandal wood oil resembles copaiba in many respects, as well as the terebinthinous oils in general. It is readily absorbed and pretty promptly eliminated, appearing both in the urine and in the exhalation from the lungs. It is slightly astringent, and fre-

quently followed by discomfort in the stomach and dryness of the throat; occasionally it causes vomiting and colic. Disagreeable eructations and its taste are complained of by some patients, but on the whole it is less unpleasant than copaiba. Its elimination by the kidneys, which is sometimes accompanied by a feeling of tension there, changes the odor of the urine, and causes it to become cloudy with acid, in the same way as copaiba; alcohol, by clearing up this cloudiness, which is caused by a resinous precipitate, will distinguish it from albumen. The sandal wood products in the urine exert a beneficial action upon vesical, and especially gonorrhœal, inflammations, equal to, if not better than, that of copaiba or cubebs, for which it is an efficient and rather more elegant substitute. It is especially serviceable in recent acute cases with considerable discharge.

Administration.—This is simple enough. Dropped upon sugar, or shaken with mucilage, it can be easily taken by those who do not mind its disagreeable taste, but probably more than nine-tenths of it is given in gelatine capsules, where it is often mixed with copaiba or cubebs. Dose, from five to twenty drops—ten is a good average—four or five times a day. It should be continued a week or so after the symptoms have disappeared.

Allied Plants.—There are eight known species of *Santalum*, all closely related. They are inhabitants of India, Australia, and of many of the Pacific Islands; all are fragrant, and perhaps others than *S. album* may contribute to the yield of East Indian sandal wood. *S. Yasi* Seem, of the Fiji Islands, *S. Freycinetianum* Gaudich, and *S. Pyrularium* Gray, of the Sandwich Islands, and several species in Australia, furnish both wood and oil. The order is a rather small one, comprising some two hundred species, mostly shrubs or trees, and often root-parasites. The source of West Indian and South American "Oil of Sandal" is not known. It resembles in its odor and taste the East Indian oil, but is cruder and less agreeable. It is very much cheaper, and is the kind usually dispensed for medicine, the other being reserved for perfumery.

Allied Drugs.—From a medical point of view Copaiba and Cubebs are most nearly related to the subject of this article. As an astringent of the intestinal and urinary mucous membranes it may be compared with Turpentine, to which it is inferior; as an alterative to bronchial secretion, for which purpose it is sometimes given, Grindelia is superior; in cystitis, etc., it is comparable with the balsams, as well as Buchu, Uva Ursi, etc. The red saunders, or red sandal wood, resembles this product only in name.

W. P. Bolles.

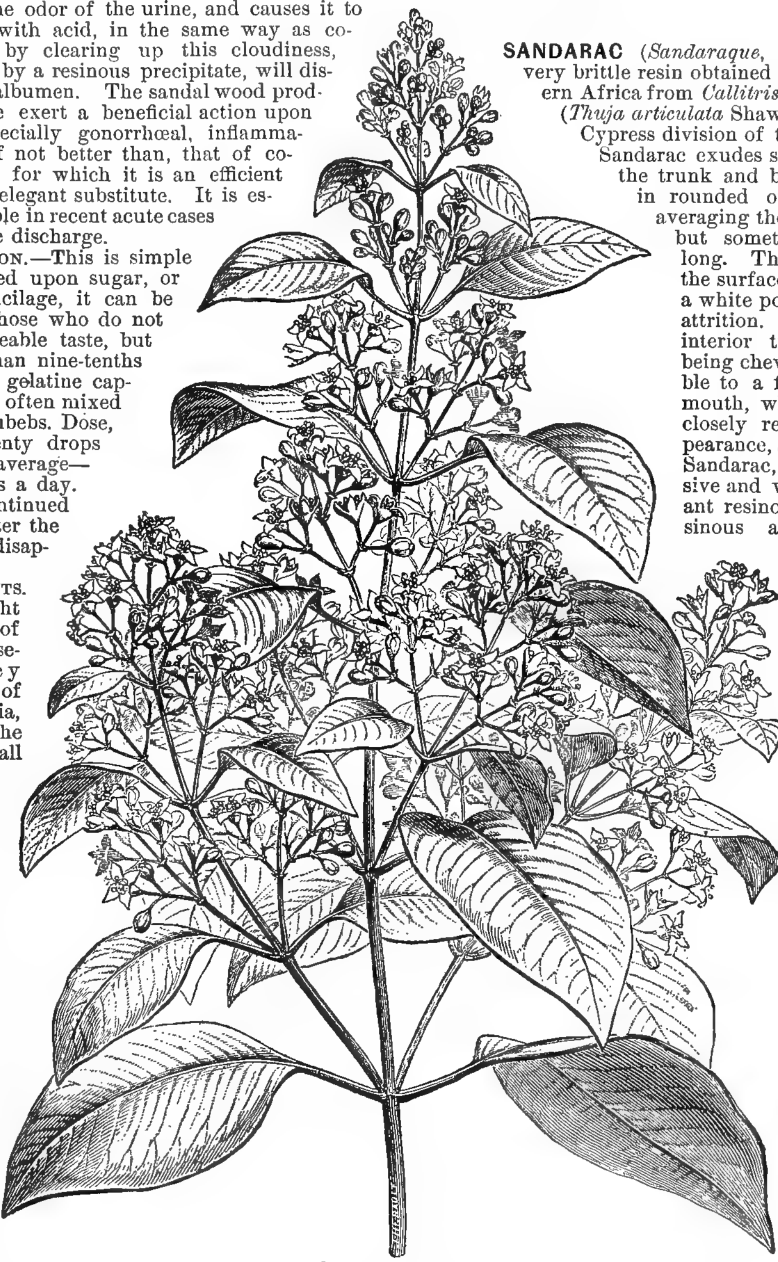

Fig. 3367.—Flowering Branch of Sandal Wood Tree, about Natural Size. (Baillon.)

SANDARAC (*Sandaraque*, Codex Med.). A very brittle resin obtained in tears in Northern Africa from *Callitris quadrivalvis* Vent. (*Thuja articulata* Shaw), a member of the Cypress division of the order *Coniferæ.* Sandarac exudes spontaneously from the trunk and branches, and dries in rounded or irregular drops averaging the size of small peas, but sometimes larger and long. The tears are dull on the surface and covered with a white powder produced by attrition. Fracture glassy, interior transparent. Upon being chewed the tears crumble to a fine powder in the mouth, while Mastic, which closely resembles it in appearance, softens. Powdered Sandarac, which is non-adhesive and white, with a pleasant resinous odor, and a resinous and bitter taste, is called "Pounce," and was formerly used to rub over the surface of paper where an erasure had been made, to prevent the ink from running when it was written over again. Sandarac is not used at present in medicine. This resin is a compound one, consisting of at least two, having different degrees of solubility in alcohol, ether, etc.

Allied Plants, Etc.—See Turpentine.

W. P. Bolles.

SANDEFJORD is a Norwegian health-resort, pleasantly situated on a fjord at a short distance from the sea. In addition to the sea-bathing, therapeutic use is made of the several mineral springs here found. Sea-mud, containing sulphur, iron, and common salt, is used in the form of baths, poultices, and as a local application applied with friction.

Sandefjord enjoys considerable reputation as a resort for those suffering from chronic rheumatism, neuralgia, nervous prostration, chronic joint diseases and other so-called scrofulous affections. The season extends over

the months of June, July, and August. A course of treatment occupies the usual time of three or four weeks.

The following is the composition of the three principal springs, computed in grammes per litre :

	Alum-iron Spring (Analysis of Hiortdahl, 1886).	Saline Spring (Hiortdahl, 1885).	Iron-saline sulphur Spring (A. Strecker, 1854).
Sodium chloride	......	3.9066	16.8877
Lithium chloride	......	trace	......
Calcium chloride	......	0.1221	......
Potassium chloride	......	0.0632	......
Potassium bromide	......	0.0005	......
Magnesium chloride	0.0187	......	2.2149
Magnesium bromide	......	......	0.0639
Calcium sulphate	0.7582	0.0248	0.5821
Magnesium sulphate	0.4650	......	......
Sodium sulphate	0.1114	......	......
Potassium-sulphate	0.0381	......	0.5282
Ferrous sulphate	0.2442	......	......
Ferric sulphate	1.0542	......	......
Aluminium sulphate	0.8467	0.0009	0.0068
Calcium carbonate	......	0.0832	0.5446
Magnesium carbonate	......	0.1806	0.6814
Ferrous carbonate	......	0.0016	0 0466
Manganous carbonate	......	......	0.0080
Silicic acid	0.0642	0.0167	0.0274
Organic matters	0.0110	......	0.2271
Total	3.6117	4.4002	21.8187

The composition of the sea-mud, used for bathing and local applications, is as follows. In 1,000 parts there are of :

Clay and sand	738.0
Organic matters	99.2
Sodium chloride	41.8
Sulphuric acid	20.5
Potassium	7.8
Magnesium	11.3
Iron	41.5
Calcium	13.1
Alumina	12.5
Silica	13.9
Loss	0 4

T. L. S.

SAN DIEGO. [For a detailed explanation of the accompanying chart and suggestions as to the best method of using it, see the general article on Climate.]

The city of San Diego, California, lies upon the sloping northeast shore of a land-locked bay five and a half miles long, twenty square miles in area, and twenty-three feet deep on its bar at low water, constituting a harbor which, by competent authority, has been pronounced to be, "with the single exception of San Francisco, perhaps the best from Callao to Puget Sound" (General Emory, of U. S. Engineers, quoted by a writer in the *New York Times* of May 9, 1886). The town is the most southerly of any in California, lying in the extreme southwestern corner of the State, only fifteen miles distant from the Mexican border, and its latitude is almost precisely the same as that of Yuma, Arizona, from which it is distant about one hundred and fifty miles in a westerly direction. From San Francisco it is distant nearly five hundred miles in a direction S.E. by S. The population in 1880 was less than three thousand; it is now (1887) estimated at about seven thousand. The slope of the hill upon which the town is built is three hundred feet to the mile; hence the natural facilities for drainage must be good. Concerning the soil, I possess no information save that the writer in the *New York Times*, already cited, states that "there is little mud and the ground dries in a few hours after the heaviest rain." The water-supply of the town was formerly deficient, but Dr. Chamberlain, in a paper read before the New York Academy of Medicine in October, 1886, says of this defect that it is one which he believes is soon to be remedied. There are good hotels at San Diego. As may be seen from the chart opposite, the winter climate of San Diego, so far as mean temperature is concerned, is about the same as that of Los Angeles, but the daily range is much less than at Los Angeles, and a decidedly greater equability of temperature throughout the year is found at San Diego, on the coast, than at Los Angeles, amông the hills and seventeen miles back from the coast. San Diego has a less rainfall, but a more cloudy sky and markedly more humid atmosphere than has Los Angeles. In point of windiness the two places are almost precisely alike in winter; very similar, indeed, throughout the year. In regard to the frequency of occurrence of fogs at San Diego, I find two contradictory statements: that of the writer in Appleton's "Handbook of Winter Resorts" (1886–1887), who says of San Diego that "there is no fog, as in Santa Barbara and more northern latitudes, and very little moisture in the air," and that of Dr. Chamberlain (loc. cit.), who tells us that the local climate of San Diego is "unsurpassed in the matter of temperature," but is damp; for while the "rains are few," the "fogs are frequent." Dr. Chamberlain also speaks of the fogs at Santa Barbara. Dr. H. S. Orme, president of the California State Board of Health, in his interesting pamphlet entitled "The Climatology and Diseases of Southern California," tells us that "from the time of the first rains the belt of country next the coast is bathed in an atmosphere which is tolerably moist," and that "at a distance of a few miles inland the relative humidity increases, not because there is more moisture, but because the temperature is apt to range lower." In this belt, he tells us, "the fogs are heaviest and the deposition of dew is greatest;" while beyond it, "as the distance from the coast increases, the relative humidity decreases until, at the crest which separates the Pacific slope from the Great Basin the air throughout the year is dry, pure, and invigorating." The limits of the belt of country characterized by an especially frequent occurrence of fogs, and by greater relative humidity than elsewhere throughout the Southern California region, cannot be very accurately defined; but to the seaward it is in general bounded and defined by a line drawn parallel to and at a distance of five miles back from the coast. Probably it is only close to its seaward border that this district is damper than the coast belt itself. Its inland border I can by no means determine, for while Dr. Lindley (see his paper quoted in article Los Angeles and Pasadena) speaks of an elevation of one thousand feet as the inland limit of the region wherein fogs "sometimes come in from the sea," and the atmosphere "during the winter months is somewhat moist," we see from the chart of Los Angeles, a point only seventeen miles back from the sea, and 283 feet above its level, that the relative humidity in winter is decidedly less than in summer; while a comparison of column J in the Los Angeles chart with the same column in the San Diego chart shows that, month by month throughout the entire year, the relative humidity of Los Angeles is very markedly less than that of San Diego, a place not lying within this belt of especially great humidity, frequent fogs, and heavy dewfall, but upon the coast which, according to Dr. Orme, is drier and less liable to fogs than this belt, beginning "at a distance of a few miles inland."

The paramount importance of a careful study of each "climat de localité" in Southern California has already been urged in the article on Los Angeles and Pasadena, is well recognized by all authorities on this subject whom I have consulted, and is probably exemplified before the eyes of the reader who has followed us through what has just been said respecting the somewhat misty limits of this belt of winter dampness and spring fogs.

A brief and necessarily general discussion of the climate of Southern California taken as a whole, and of its undoubtedly great adaptation to the purpose of a health region for the resort of phthisical and other invalids during the winter season, or during the entire year, has already been presented in the article entitled "Los Angeles and Pasadena." To what is said in that article, and in particular at its close (page 582 of vol. iv.), I have nothing to add, merely repeating here, in slightly different form, what I have said before, viz., that for many invalids Southern California is not only a good winter residence, but is a health-giving and health-restoring home for residence all the year round; and this in no small

Climate of San Diego, Cal.—Latitude 32° 43′, *Longitude* 117° 10′.—*Period of Observations, November* 1, 1871, to *December* 31, 1883.—*Elevation of Place of Observation above Sea-level*, 49 *feet.*

	A			AA	B		C	D	DD	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Mean daily range deduced from columns C and D.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January ...	48.0	60.4	52.6	53.6	57.4	50.4	61.8	44.5	17.3	78.0	64.0	44.0	32.0	22	24
February ..	49.1	60.3	53.5	54.3	57.9	50.8	61.6	46.3	15.3	82.6	63.0	45.0	35.0	25	17
March	50.8	61.3	54.9	55.6	58.9	52.1	62.8	49.0	13.8	99.0	63.0	48.0	38.0	27	19
April.......	52.5	63.6	57.0	57.7	60.8	56.0	65.3	51.2	14.1	87.0	67.0	51.0	39.0	18	20
May........	56.6	66.2	60.0	60.9	62.6	60.0	68.5	55.3	13.2	94.0	68.0	52.0	45.4	23	21
June	60.5	69.6	63.2	64.4	66.6	62.7	71.7	58.9	12.8	94.0	73.0	58.0	51.0	17	21
July........	63.5	72.2	65.6	67.1	68.7	63.4	73.5	61.9	11.6	86.0	73.0	62.0	54.0	26	24
August.....	65.0	73.7	67.4	68.7	71.2	65.8	74.9	63.1	11.8	86.0	78.0	64.0	54.0	27	26
September .	62.7	72.2	65.6	66.8	69.7	63.1	74.5	60.4	14.1	101.0	78.0	59.0	49.5	26	17
October	58.1	69.1	61.4	62.8	67.2	61.2	70.2	55.0	15.2	92.0	72.5	53.0	44.0	30	16
November..	52.5	65.7	56.6	58.2	60.6	56.2	66.8	48.7	18.1	85.0	75.0	50.0	33.0	22	23
December..	50.0	62.7	54.1	55.6	57.5	53.3	64.5	49.0	15.5	82.0	68.0	44.0	32.0	24	15
Spring	......	......	......	58.0	59.2	56.4	....	....	13.7	......	......	......	......		..
Summer ...	......	......	......	66.7	68.1	64.1	....	....	12.0	......	......	......	......	..	..
Autumn ...	......	......	......	62.6	65.1	60.2	....	....	15.8	......	......	......	......	..	.
Winter.....	......	......	......	54 5	57.4	52.2	....	....	16.0	......	......	......	......	.	..
Year	......	......	......	60.4	62.1	58.5	....	....	14.8	......	......	......	......		..

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind per hour.
						Inches.	From	Miles.
January ...	46.0	71.2	11.2	11.3	22.5	1.85	NE.	5.1
February ..	47.6	74.3	11.3	9.0	20.3	2.07	NW.	6.0
March	61.0	75.5	12.7	8.7	21.4	0.97	W.	6.4
April.......	48.0	72.4	11.9	10.2	22.1	0.68	W.	6.6
May........	48.6	73.0	12.1	8.0	20.1	0.26	W.	6.7
June.	43.0	73.8	15.2	6.7	21.9	0.05	W.	6.3
July........	32.0	76.4	16.1	8.2	24.3	0.02	W.	6.3
August.....	32.0	77.1	16.9	9.4	26.3	0.23	W.	6.0
September..	51.5	76.4	13.9	11.7	25.6	0.05	NW.	5.9
October	48.0	71.5	12.6	12.8	25.4	0.49	NW.	5.4
November..	47.0	66.4	10.0	13.5	23.5	0.70	NW.	5.1
December ..	50.0	67.2	11.2	13.2	24.4	2.12	NE.	5.1
Spring	61.0	73.6	36.7	26.9	63.6	1.91	W.	6.6
Summer....	63.0	75.8	48.2	24.3	72.5	0.30	W.	6.2
Autumn....	63.0	71.4	36.5	38.0	74.5	1.24	NW.	5.5
Winter	50.6	70.9	33.7	33.5	67.2	6.04	NE.	5 4
Year........	69.0	72.9	155.1	122.7	277.8	9.49	W.	5.9

degree by reason of the very considerable varieties of climate which are therein to be found comprised within a comparatively limited area of territory.

In conclusion, and as emphasizing the equability of the climate of San Diego, the place now under our special consideration, and, as illustrating its immunity from even occasional extremes of heat and of cold, I quote the following data, derived from Appleton's "Handbook of Winter Resorts," from Dr. Orme's pamphlet, and from the letter to the *New York Times* of May 9, 1886, already quoted above. During the ten years 1876 to 1885 the mercury at San Diego rose above 80° F. on only one hundred and twenty days (*i.e.*, on an average but twelve times in each year); and it went above 95° F. on only six days. During the same period it fell below 40° F. on only ninety-three days, an average of but nine days in each winter; and on no day did it remain below 40° F. more than two or three hours, and this between midnight and daylight. It fell below 35° F. on six occasions only throughout the whole period of ten years, and never once fell below 32° F. Says the *Times* correspondent, commenting upon these figures: "There is therefore no such difference between summer and winter, or between day and night, as to prevent one from wearing the same clothing and sleeping under the same cover all the year round."

During the year 1880 the thermometer at San Diego rose to 90° F. only six times, while at Los Angeles this temperature was reached fourteen times (Dr. Orme, *op. cit.*).

The general healthfulness of Southern California has been alluded to in the account of Los Angeles (vol. iv.), and a table printed on pages 10 and 11 of Dr. Orme's pamphlet, which shows the prevalence at each of twenty-four towns of the diseases occurring throughout this region in the year 1884–85, reveals the fact that San Diego compared very favorably with any of the other points specified. For phthisical invalids it is probably not quite so suitable a winter residence as are Pasadena and other inland points. *Huntington Richards.*

SAN FRANCISCO. The chart on next page, obtained from the Chief Signal Office, at Washington, represents the climatic conditions prevailing at the city of San Francisco, Cal. (For a detailed explanation of the chart and suggestions as to the best method of using it, see article Climate, vol. ii., pp. 189–191.)

Whatever may be the advantages of the winter climate at San Francisco when compared with that found at places of corresponding latitude in the eastern and central portions of the United States, it is very much less mild than that found at points lying further south in the same State, and particularly at such as lie to the south of the Tehachipi and Santa Ynez mountain ranges, in what is known as Southern California. As for the summer climate, it is by very common consent pronounced to be exceptionally disagreeable; and is by no means suited to the benefit of invalids affected with any form of pulmonary disease.

The situation of San Francisco, at the mouth of a gap through which the cool air lying over the surface of the Pacific is sucked up to supply the place of the heated air radiated from the great inland basin comprising the Sacramento and San Joaquin Valleys, is the cause of its peculiar, and to most persons very disagreeable, summer climate. The hotter it is at this season in the interior, the colder and more windy will it be in San Francisco, a fact which is well corroborated by the data in the accompanying chart. The windiness of the summer season, as compared with other parts of the year, is plainly to be seen in the data of Column S. The direction of the prevailing wind at this season, the high relative humidity of July, August, and September, the low absolute and average daily maxima, and the small mean daily range of July and August as compared with those of June and

Climate of San Francisco, Cal.—Latitude 37° 48′, *Longitude* 122° 26′.—*Period of Observations, March* 8, 1871, *to December* 31, 1883.—*Elevation of Place of Observation above the Sea-level,* 13 *feet.*

	A. Mean temperature of months at the hours of			AA. Average mean temperature deduced from Column A.	B. Mean temperature for period of observation.		C. Average maximum temperature for period.	D. Average minimum temperature for period.	DD. Mean daily range of temperature deduced from columns C and D.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Degrees.
January....	47.8	53.1	50.1	50.3	54.6	46.5	54.5	45.9	8.6
February...	48.6	55.1	51.9	51.8	55.7	47.9	57.9	46.5	11.4
March......	49.8	57.4	52.9	53.3	57.0	48.9	59.5	48.7	10.8
April.......	50.5	59.0	53.4	54.3	57.1	52.3	60.6	49.7	10.9
May........	52.1	61.4	55.2	56.2	57.5	54.3	63.8	51.7	12.1
June........	54.3	64.0	57.3	58.5	61.7	56.0	65.0	53.4	11.6
July........	54.6	63.1	56.8	58.1	59.9	56.6	64.8	54.2	10.6
August.....	55.0	63.5	57.2	58.5	59.7	57.6	64.7	53.9	10.8
September..	55.7	65.4	58.4	59.8	62.1	58.3	67.0	54.5	12.5
October.....	55.2	64.2	58.5	59.3	61.8	55.9	65.0	53.5	11.5
November..	52.2	59.0	55.7	55.6	57.9	52.5	60.1	53.0	7.1
December..	48.8	53.9	52.1	51.6	53.2	49.4	55.9	44.8	11.1
Spring......	......	......	......	54.6	56.3	52.9	....	....	11.2
Summer....	......	......	......	58.3	60.2	57.1	....	....	11.0
Autumn....	......	......	......	58.2	59.4	56.2	....	....	10.8
Winter......	......	......	......	51.2	54.4	48.2	....	....	10.3
Year........	......	......	......	55.6	57.3	54.2	....	....	10.7

	E. Absolute maximum temperature for period.		F. Absolute minimum temperature for period.		G. Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	H. Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	69.0	58.0	46.0	36.0	24	30
February...	70.5	61.0	47.0	35.0	[illegible]	24
March......	77.0	62.0	48.0	39.0	31	19
April.......	81.0	63.0	48.0	40.0	25	20
May........	86.0	71.0	50.0	45.0	22	15
June........	95.2	67.0	52.5	48.0	28	13
July........	83.0	66.0	53.0	49.0	27	20
August.....	89.0	69.0	54.0	50.0	17	17
September..	92.0	69.0	53.0	50.0	25	22
October.....	84.0	72.0	52.0	45.0	23	[illegible]
November..	78.0	64.0	50.0	41.0	[illegible]	23
December..	68.0	59.0	44.0	34.0	13	22
Spring......	......	......	......	......	......	......
Summer....	......	......	......	......	......	......
Autumn....	......	......	......	......	......	......
Winter......	......	......	......	......	......	......
Year........	......	......	......	......	......	.....

	J. Range of temperature for period.	K. Mean relative humidity.	L. Average number of fair days.	M. Average number of clear days.	N. Average number of fair and clear days.	O. Average rainfall.	R. Prevailing direction of wind.	S. Average velocity of wind, in miles, per hour.
						Inches.	From	
January....	33.0	72.8	9.6	12.0	21.6	5.10	N.	7.2
February...	35.5	73 3	10.3	9.6	19.9	3.95	W.	7.3
March......	36.0	72 3	11.4	11.8	23.2	2.88	W.	8.9
April.......	41.0	71.8	11.3	12.4	23.7	1.80	W.	10.1
May........	41.0	72.0	10.2	15.0	25.2	0.71	W.	11.3
June........	47.2	73.8	11.2	12.6	23.8	0.16	S.W.	12.6
July........	34.0	78.9	15.7	7.7	23.4	0.01	S.W.	12.9
August.....	39.0	80 0	14.4	9.7	24.1	0.01	S.W.	12.1
September..	42.0	77 5	13.1	12.4	25.5	0.15	S.W.	9.9
October.....	39.0	72.3	11.4	15.4	26.8	1.13	S.W.	7.8
November..	37.0	71.1	9.4	15.0	24.4	2.70	N.W.	6.1
December..	34.0	76.0	9.6	13.1	22.7	4.72	N.	6.4
Spring......	47.0	72.0	32.9	39.2	72.1	5.39	W.	10.1
Summer....	47.2	77.6	41.3	30.0	71.3	0.18	S.W.	12.5
Autumn....	51.0	73.6	38.9	42.8	76.7	3.98	S.W.	7.9
Winter......	36.5	74.0	29 5	34.7	64.2	13.77	N.	7.0
Year.......	61.2	74.3	137.6	146.7	284.3	23.32	S.W.	9.4

September, all point in the same direction, and receive their full explanation in the following passages, which are taken from Blodget's "Climatology of the United States," and are quoted by the author of that work from the writings of Dr. Gibbons, of San Francisco. The first of these passages discusses the increase in the force and frequency of the sea-winds during the summer season.

"Whatever may be the direction of the wind in the forenoon in the spring, summer, and autumn months, it almost invariably works around to the west in the afternoon. So constant is this phenomenon that in the seven months from April to October, inclusive, there were but three days on which it failed to do so, and these were rainy. The sea-winds are moderate until May, when they begin to give trouble. In June they increase in force, reaching their greatest violence at the beginning of July. In August they decline in force, but not in constancy; in September they continue steady, though moderate; and in October they lose their annoying qualities, and become gentle and agreeable."

What these "annoying qualities" are will appear from the second passage quoted from Dr. Gibbons, wherein he describes the course of a summer day at San Francisco:

"The sun shines forth with genial warmth, the mercury rising generally from 50° at sunrise, to 60° or 65° at noon; but when the sun has reached the zenith the wind rapidly increases, coming down in gusts from the hills which separate the city from the ocean,* and often bringing with it clouds of mist. But the dampness is never sufficient to prevent the elevation of clouds of sand and dust which sport through the streets in the most lively manner. The mercury falls suddenly, and long before sunset fixes itself within a few degrees of 50°, where it remains pertinaciously till next morning, often not moving a hair's breadth for twelve hours. . The mist often increases toward evening, and when the wind falls remains all night in the shape of a heavy fog. Sometimes, when the sun has been shining brightly, the mist comes in from the ocean in one great wave and suddenly submerges the landscape. In short, there is no conceivable admixture of wind, dust,† cloud, fog, and sunshine that is not constantly on hand during the summer at San Francisco."

This fog, we are told by Mr. Blodget, does not blow in from the sea, but is formed on the spot by contact of the cold sea-air with the naturally warmer land-air. The sea-breeze in summer is a more or less cold breeze, he tells us, all the way down the coast as far as the extremity of the peninsula of Lower California, at Cape St. Lucas; but at San Francisco its coldness is most marked, because the indraught of air at that point is vastly stronger than elsewhere, for reasons which will be found fully explained in his work, and which have been already briefly referred to in this article.

San Rafael, a town of some three thousand inhabitants (population in 1880, 2,276) lying twelve miles north of San Francisco, about three miles from the shore of San Pablo Bay (a subdivision of the great gulf comprising San Francisco, San Pablo, and Suisun Bays, which is entered through the Golden Gate), is a place much better sheltered from the direct influence of the sea-winds than is San Francisco, and on this account possesses a much more agreeable climate. "The scenery about San Rafael and in the approaches to it is extremely fine . . and the air is pure and bracing, and, though hardly warm enough for consumptives in advanced stages of the disease, is admirably adapted for

* Blodget's Climatology was published in 1857. Dr. Gibbons's meteorological observations at San Francisco covered the period of sixteen months, from December, 1850, through March, 1852.

† The dust is less troublesome now than at the time when this account was written, more than thirty years ago, the streets of the city being kept carefully watered.

such as are in the preliminary stages, and only need a dry and tonic climate inviting to an out-door life" (Appleton's "Handbook of Winter Resorts," 1886-87). The hills which lie close about San Rafael on its western aspect, that is, on the side toward the ocean, are quite high (1,500 feet according to a writer in the New York *Daily Graphic* of January 22, 1885), and, moreover, the distance in a direct line to the sea-coast is, in a southwesterly direction ten miles, in a westerly direction twenty miles. I have no data to illustrate the superiority of San Rafael over San Francisco in point of climate. Monterey, a small town lying directly upon the Pacific coast, at the southern extremity of the Bay of Monterey, and at a distance of about one hundred miles from San Francisco in a SSE. direction, has acquired some reputation during late years as a pleasure and health-resort, and a large hotel has been built there by the Southern Pacific Railway. Through the kindness of Dr. C. B. Currier, of San Francisco, I received, some two years ago, a printed table showing the absolute monthly maximum and minimum temperatures, the mean daily temperature, and the total rainfall for each of the fifty-four months, July, 1880, to December, 1884, inclusive. The observations of which these data are the record were taken at the hotel just mentioned; the hours of observation I do not know.

Monterey Temperature and Rainfall.

	AA	B		T	V	E		F		O
Month.	Average Mean temperature.	Mean temperature.		Average of monthly maxima.	Average of monthly minima.	Absolute maximum temperature.		Absolute minimum temperature.		Average rainfall in inches.
		Highest.	Lowest.			Highest.	Lowest.	Highest.	Lowest.	
January	49.55	53.67	46.75	63.33	35.41	70.00	57.00	45.00	27.00	2.38
February	52.30	56.28	50.60	69.33	37.66	82.00	58.66	52.00	28.00	3.03
March	55.41	56.82	54.29	70.33	45.16	84.00	60.66	49.66	40.00	4.73
April	58.45	62.26	56.83	67.58	50.41	71.00	63.33	58.00	45.00	2.03
May	60.73	62.74	59.68	74.75	53.33	87.00	66.00	58.00	50.00	0.42
June	63.13	64.92	61.13	72.83	58.41	87.00	67.00	62.66	55.00	0.52
July*	64.21	66.42	61.01	73.63	59.02	84.00	67.50	63.33	53.00	0.00
August*	62.89	64.85	61.09	70.99	56.59	77.00	66.66	61.33	50.00	0.01
September*	61.46	63.26	57.52	74.06	53.73	85.00	66.66	60.00	44.00	0.11
October*	57.17	59.55	54.39	68.53	47.40	77.00	60.66	55.00	37.00	1.19
November*	51.79	52.58	51.13	64.79	40.73	71.00	58.66	46.00	32.00	0.82
December*	52.16	53.87	50.81	64.26	40.80	73.00	58.33	49.33	30.00	2.99

* Observations of five years. For the other months the observations covered only four years.

From this table, sent by Dr. Currier, I have deduced by calculation the data standing in columns AA, T, V, and O of the chart herewith presented; the figures in the remaining columns (B, E, and F) are copied directly from the table, but are differently arranged. The columns of this chart may be compared with corresponding columns of the San Francisco chart (and of other Signal Office charts), but in doing so the reader should bear in mind that the period of observations at Monterey was a very short one, the hours of observation perhaps different from those adopted by the Signal Service, and the method of taking maximum and minimum observations unknown to me. A careful study of the chart not only shows that Monterey possesses a mild winter and a cool summer climate, but also reveals facts which bear out the observations made by Mr. Blodget, to the effect that the peculiarity already noticed in the summer climate of San Francisco exists also at other points upon the coast, but that it is very much less marked at places lying to the south of San Francisco than it is at San Francisco itself. Columns T and V by no means correspond to columns C and D of the Signal Office charts; the former give the average of *monthly*, the latter of *daily*, maxima and minima.

Huntington Richards.

SANICLE, Codex Med., *Sanicula europæa* Linn., order *Umbelliferæ.* A small European perennial with palmate or reniform, five-lobed leaves, unisexual flowers, and ovoid spiny fruits. It contains tannin, bitter extractive, and resin. Sanicle is a household herb of Europe, and used both internally and externally in numerous conditions. It probably has no value. *W. P. Bolles.*

SANITARY INSPECTION, PRINCIPLES OF. This is a comprehensive subject, as it relates to inquiries into all influences affecting or tending to affect injuriously the health of a locality. It involves a knowledge of the importance of perfect purity and cleanliness of air, water, food, and soil as the fundamental and paramount conditions of health, and seeks to discover and guard against or counteract those influences which are liable to render impure these essentials to the maintenance of healthy life. It is through this important public service that the local health authority is kept informed of those conditions which tend to endanger the health of the inhabitants, and that knowledge is obtained with regard to the sanitary state of the people, and the preventable causes of sickness and death, which forms the basis of all intelligent and efficient sanitary legislation and administration.

Sanitary inspection is not restricted in its objects simply to the collection of information which is indispensable to the application of the provisions of the public health laws; it also includes the execution of the provisions of such laws whenever the circumstances of the case may justify and require it. An executive service is the natural and necessary complement of an inspection service, inasmuch as the purpose of the latter, in detecting all such influences as are injurious to the public health, is to suggest and make possible the proper steps for their removal.

The causes of disease with which public hygiene is concerned, such as affect the mode of life of masses of population, operate through a great variety of channels, and their discovery and removal require the exercise of knowledge affecting the various conditions under which people live, whether in the city, town, or hamlet. Such knowledge relates to the natural and acquired features of the locality, its meteorological peculiarities, and the social and sanitary state of its population; the character of the soil, ground-water, wells, and springs; the water-supply; plans of drainage and sewerage; the distribution of buildings and of open spaces, whether paved or unpaved; the sanitary arrangements of houses, especially those of the poorer classes; the management of burial-grounds and the arrangements for the burial of the dead; the nature of manufacturing and other industrial establishments; the housing of the poor, and the facilities afforded for bathing, washing, etc.; the conduct of slaughter-houses and all establishments where food-supplies are prepared; the examination of foods with respect to their wholesomeness; the sanitary inspection of schools and school children; the regulations for cleansing the public ways and markets, and for the removal and disposal of domestic and trade refuse; the examination of persons and houses with the object of restricting or suppressing contagious or infectious diseases of local origin, and of vessels and passenger-trains in order to prevent the introduction of such diseases from without.

While the intelligent exercise of the functions of the sanitary inspector requires a familiarity with these various subjects, a high degree of efficiency is more surely attained by a division of labor according to special branches of inquiry, a plan which yields the advantages of more matured experience and greater precision of knowledge. Besides the ordinary nuisance inspectors and inspectors of quarantine, it is becoming more and more customary to appoint officers fitted for particular lines of work by special education and training. In order to prevent the sale of adulterated and unwholesome foods and drugs, it is necessary to have officers who, in addition to other qualifications, shall possess a knowledge of chemical analysis and microscopical examination. The sanitary inspection of school buildings and the supervision of the health of the children are wisely entrusted to men who have had a medical training. The sanitary supervision of house-drainage and plumbing required under the laws recently established in many American cities, imposes upon the local health boards the duty of employing experts skilled in the technics of this art. The examination of immigrants and travellers, with the object of preventing the introduction and spread of dangerous communicable diseases, is another special branch of sanitary inspection which none but a medical officer is qualified to conduct.

Qualifications of Sanitary Inspectors.—Efficient sanitary inspection depends primarily upon an adequate knowledge of the various subjects relating to hygiene and public health, and the officers employed in it should be fitted for the work by special and sufficient education. As many of these subjects relate to diseases, their causes, mode of propagation, and the means of their suppression, a medical knowledge becomes an essential qualification of at least a portion of the force employed as sanitary inspectors by a board of health. Under the English health laws the officer of health, whose duties are largely those of an inspecting officer, must be qualified by law to practise medicine or surgery, though such qualification is not made necessary in the case of inspectors of nuisances.

Intelligent sanitary inspection rests upon a knowledge of the following subjects:

1. The principles of chemistry, particularly with regard to the methods of analysis (including microscopical investigation). Such knowledge is indispensable in forming accurate judgment as to impurities of air and water, injurious impregnations of the soil, harmful admixtures in food, and also in the proper use of disinfectants. An acquaintance with chemical physics, including the chief phenomena of light, heat, and electricity, is also advantageous.

2. Natural philosophy, which should embrace a thorough knowledge of the principles of pneumatics, hydrostatics, and hydraulics, with special reference to ventilation, water-supply, drainage, construction of dwellings, and sanitary engineering in general. The laws of natural philosophy will be of great aid in tracing nuisances, in determining questions of ventilation and of overcrowding, and in studying atmospheric changes; and, in conjunction with chemistry, will be of the greatest service in the investigation of industries and trades alleged to be prejudicial to health, and in devising measures for the abatement of the evils associated with them.

3. A knowledge of the laws relating to public health.

4. The sanitary construction and arrangements of dwellings, including soil, structure, materials, internal decoration, lighting, ventilation and warming, water-supply, house and soil drainage, and disposal of refuse.

5. A knowledge of the effects of overcrowding, vitiated air, impure water, bad or insufficient food, unhealthy occupations, and of the diseases they produce; the character of nuisances injurious to health, the disposal of sewage, and the effects of soil, season, and climate upon the health of localities.

6. A knowledge of the causes, propagation, and prevention of contagious and infectious diseases. In addition to a familiarity with the above subjects, there should be the further qualifications of methodical and industrious habits, competent powers of observation, sound judgment, and conscientiousness in the investigation and statement of facts.

It may be objected that the qualifications outlined above are too comprehensive, and that the knowledge deemed essential for the performance of the duties of sanitary inspector is such as should only be required of a professional expert. But it should be remembered that sanitary inspection is pre-eminently the service by which information is obtained of the numerous and various conditions which operate against the health of a locality, and constitutes a large and important part of the work of sanitary government. In order to recognize and intelligently investigate these conditions, and advise as to the means of their amelioration or removal, a comprehensive knowledge of the principles and laws of science involved in their consideration is indispensable. Efficient sanitary inspection requires skilled or expert labor, which can only be secured by special knowledge and experience.

Sanitary Survey.—A systematic sanitary survey of a locality is the true basis of measures for its sanitary improvement. Such a survey embraces an investigation of the natural and artificial or acquired conditions affecting the health of the inhabitants in the district.

The natural conditions affecting the health of a district comprise the geological and topographical characteristics of the locality, the climate, water-supply, etc. The causes of many of the most common diseases arise from conditions connected with the earth's surface and underlying structure, as well as with the soil polluted by the act of man. The influence exerted upon human health by the drainage of a locality, by the moisture in the soil, the ground-water, and telluric emanations, has long been recognized, but the exact effects of these conditions cannot be rightly understood without a knowledge of the physical characteristics of the soil, studied in their relations to the records of diseases in their geographical distribution and local history. These two series of facts, studied side by side, lead to the interpretation of the laws governing the relations of the earth's features to health and disease. Detailed and exact records of the configuration of the earth's surface and its underlying structure, illustrated so far as possible by means of maps and diagrams, form the basis of correct knowledge of sanitary geography and local hygienic history. It is only by the aid of these facts that the health of a town or district and the records of prevalent diseases can receive their proper explanation.

The influences of climatic conditions upon health are also to be investigated in connection with the natural local conditions. The daily temperature and rainfall, the force and direction of the wind, the barometric pressure, degree of humidity, etc., should be subjects of careful observation and record. In many places these data can now be obtained from the Signal Service Bureau of the Government. In districts where such observations are not recorded, arrangements should be made for obtaining the necessary information. The meteorological fluctuations exert a powerful influence on health and disease, and though they are beyond the control of man, a knowledge of their effects will be most useful in the investigation of other local conditions more amenable to human effort, and in assigning to them their proper share of hurtful influence.

The quantity and quality of the water-supply of a district depend mainly on its geographical and topographical characteristics, which must be studied in their relations to this important fact. The quality of water is necessarily affected by the character of the soil through which it flows and by the surface upon which it is collected. A water may become so thoroughly impregnated with mineral or vegetable matters contained in the soil, or with organic matter upon its surface, as to be unfit for domestic use. A wholesome water may become polluted by the transmission of impurities through the porous structure of the ground. In locating wells the physical characteristics of the soil should be taken into consideration with reference to the risks of pollution of the supply.

Soil moisture and the state of the ground-water play an important rôle in the causation of disease. These natural characteristics of the soil depend on certain combinations of geological and topographical structure, which must be investigated in every locality before improvements necessary to secure healthfulness can be intelligently undertaken. Before drying and aerating the soil one must have a knowledge of its natural drainage and physical conditions. No plans of artificial drainage or of sewerage can be satisfactorily accomplished without a thorough comprehension of the natural drainage system of the district.

The acquired conditions affecting health relate to the habitations of the population, the water-supply, the drainage and sewerage, removal of refuse matters, public ways and places, gas and lighting, slaughter-houses and abattoirs, markets, food-supplies, manufactures and trades, public school buildings, hospitals and public charities, police and prisons, fire establishments, cemeteries and burial, the arrest of contagious and infectious diseases, etc. A series of questions upon these and other subjects relating to municipal sanitation have been framed by the National Board of Health to serve as a guide in making a systematic sanitary survey of a district, and their practical use is exemplified by surveys taken of several cities and detailed in the reports of that Board for the year 1879, to which reference should be made. The annual volumes of the American Public Health Association also contain valuable information upon the same subject.

Sanitary Inspection of Habitations.—The health authority should, so far as practicable, have a full knowledge of the general sanitary condition of every house in the district which it controls. The acquisition of such information is of necessity a laborious undertaking, requiring painstaking and systematic search, and a considerable outlay of money; but when the record of facts is once completed its benefits will be continuous. A brief description of every house, showing the structure of the building, the facilities for ventilation, the drainage arrangements, its connection with the sewer, the nature of the water-supply, the conditions of the soil, health of occupants, number and causes of deaths that have occurred in it, and other pertinent information, should form a permanent record, and this record should be kept up by recording any changes noted upon subsequent examination. The complete sanitary history of every locality thus obtained will be useful for reference, and will serve as a guide to the discovery of unhealthy premises and the causes of their insanitary conditions, and lead to the employment of measures of improvement. By reference to the records the condition of each house at once becomes known, and the effort to determine the exciting cause of any disease therein existing will be greatly facilitated.

It is the right of everyone proposing to buy or rent a house to have a knowledge of its sanitary history. Such information is generally obtained with the greatest difficulty, because no sanitary survey has ever been made. With this as a basis the local sanitary authority ought to be able, for a small fee, to furnish to anyone proposing to occupy a house a copy of the health history of the house, certified from the records.

The tabulated forms to be used for a sanitary inspection of houses will vary slightly according as the district is urban or rural. The form presented below is a modification of the schedule of questions proposed and used by the National Board of Health, and differs in several respects from that given in the next article. The headings should be printed in tabular form, on paper of convenient size and shape, arranged in the style of a tablet.

Sanitary Inspection of Houses and Premises.

Number of Inspection Return ..... Date of inspection......
1. Ward......, Street......, No......
2. Names of occupier and of owner......
3. Area of lot......; of house......; of out-houses......
4. Site of house, wet or dry......
5. Age of house......; material......; number of stories......
6. Number of living-rooms......; of sleeping-rooms......
7. Cellars and basement.....
8. Sinks, drains, and cesspools......
9. Privies or water-closets, location and condition......
10. Yards......
11. Hogs or other animals......; fowls......; number......; where kept......
12. Public nuisances on or near premises......
13. Number of families in house......; names of heads of families ......; number of persons in each family, specifying number of whites and blacks......; total number of occupants......
14. Sickness now in house......; what diseases......
15. Sickness during past year......; what diseases......; number of cases .....
16. Deaths during past year..... ; what diseases......
17. Persons vaccinated......; persons not vaccinated......
18. Water-supply, whence derived, sources of contamination......
19. Sanitary needs and estimated cost......
20. Additional observations......

.... Certified as correct,

........................,
Inspector.

Upon the other side of the blank may be printed directions for the guidance of the inspector.

Directions: 1 and 2. Give the exact and full name of the owner and occupier of the premises. Give the street and number, and describe the location so that it cannot be mistaken.
3. Give dimensions of sheds, privies, stables, etc., with their relations to living-rooms.
4. State whether site is above, below, or upon same level as adjoining land. Conditions of the soil, whether damp, wet, or dry or "made-ground."
6. Note how ventilation is secured.
7. Examine cellars very carefully, and describe their condition, particularly with regard to dampness, amount and kind of filth, ventilation, drains, etc. State whether used for living purposes.
8. Is there any offensive smell from the sinks? Are the drains water-tight, clogged, or uncovered? Are there any traps to prevent drain-air from coming into the rooms? Are there sewer-connections, intercepting-trap, soil-pipe ventilation? Are the cesspools tightly covered, clean, and ventilated? Do the cesspools leak into the cellar or into the well?
9. Privies and vaults. Describe their condition particularly. Are they full, foul, leaky, or overflowing? Are they shallow or deep, water-tight or leaking, connected with the sewer, trapped, ventilated, etc.?
10. Describe the kind and amount of all heaps of filth about the premises, and the general condition of the yard, area, etc.
12. Public nuisances, as sewers, badly paved and drained streets, gutters, etc., stables, manufactories.
13. Note overcrowding and social condition of the inmates.
14, 15, 16, and 17. Inquire particularly.
18. State whether, in addition to the supply from the public water mains, water is used from a well or cistern; whether it is called good or bad; whether any filth probably drains into the well.
19. State what is necessary to be done to remove nuisances, and improve the sanitary condition of the premises, and the approximate cost of such improvements.

The duty of collecting information upon the subjects embraced in a sanitary inspection should be performed with great discretion, so that, while nothing necessary to be known shall escape observation, the service shall not excite opposition by its obtrusiveness and unnecessarily inquisitorial character. It must be remembered that in most cases these examinations can only be carried out by the sufferance of the people; but by tact and politeness it is possible in nearly all instances to obtain all the information desired.

Upon the completion of a general house-to-house inspection, the returns—containing a record of sanitary facts—should be tabulated, paged, indexed, and grouped by wards or districts in such a manner as to make instant reference to the original inspection of every house and locality possible. From these data sanitary ward-maps may be compiled, indicating by color the special insanitary features of a district; as, for example, insufficient or defective drainage, polluted or suspicious water-supply, unhealthy habitations, public nuisances, centres of excessive mortality, prevalence of epidemic disease, etc., these subjects being so arranged that ready reference can be made to the original records of inspection for a full description and sanitary history of any house or locality.

The frequency with which a systematic inspection of a district should be made must necessarily vary according to the extent and character of the district and other circumstances. It would be a useless task and a waste of time and money to inspect localities containing the best residences and a population of the better class, as frequently as streets and houses in poor neighborhoods, particularly such districts as are notoriously unhealthy. The latter, of course, will require most vigilant watching. At the same time, no part of a town, however favorable its sanitary reputation, should be exempt from

periodical visits, as it is only by universal and rigid scrutiny that a full record of facts favorable or otherwise to the public health can be satisfactorily obtained. Whenever made, these inspections should be thorough and systematic, so that the data secured shall represent the actual state of every part of the district.

Sanitary Inspection of the Water-supply.—An abundant supply of wholesome water is an essential to the health and comfort of man. An insufficient quantity leads to impurities of all kinds, and an impure quality is a frequent cause of disease. Experience has taught us that a community will be unhealthy in proportion as the supply of water is scanty and the quality bad, other things, of course, being equal. In providing a supply, it is to be presumed that the water commissioners have given due consideration to the quality of the water, the quantity required, and the risks of pollution, both as regards the source of supply and the mode of distribution. But this fact does not relieve the health authorities from the duty of vigilant inspection of the source, storage, and distribution of the water used for domestic purposes, in order to discover any permanent, temporary, or accidental cause of contamination. It is pertinent to such an inquiry to ascertain all facts connected with the source from which the supply is derived. If from a river or stream, whether the drainage from towns, villages, and factories, or other polluting matters flow into it above the point at which the water is taken; whether the gathering grounds are cultivated lands, enriched with night-soil or other excrement, and whether the territory from which the water is drained is sufficiently populated to seriously affect the quality of the latter; whether the supply is ample for general and domestic purposes, and is distributed to every house; whether impurities of storage are carefully guarded against, and the processes of filtration and purification are successfully conducted; whether the channels of distribution are protected from all risk of pollution, and whether the supply is always constant and the pressure in the mains sufficiently strong to insure delivery at the top of the house, if necessary, and also to prevent regurgitation.

These and other questions relating to the character of the supply should not be overlooked, but the services of the sanitary inspector will be more constantly required in searching for the sources of pollution to which water may be exposed after it has been brought into the town and into the houses. It will be necessary to inquire into the situation, construction, and condition of cisterns and tanks, the means of separation of cisterns used for domestic supply from those supplying water for the closets, the situation of the overflow-pipes, and the relation between the service-pipes and the water-closets, the object being the prevention of any influx of foul air or foul matter into the service-pipes, and the consequent contamination of the supply.

The color, taste, and smell of water will generally indicate the presence of impurity, but if this evidence is not satisfactory, more exact information should be obtained by chemical analysis. The inspector should not be required to make such an analysis, but he can carefully procure samples of the water to be submitted to a chemist who is expert in this branch of investigation.

In rural districts and in towns where the supply is collected or obtained on the premises, it is important that the state of every well and other source of water used by the inhabitants should be fully known. Rain-water stored in cisterns and well-water are liable to contamination from many sources. If the collecting surface is defiled, impurities will be washed into the cistern by the first fall of rain. Rain-water collected in the neighborhood of inhabited places is liable to contain gaseous and solid impurities washed from the air. Inspection should be made, from time to time, of the interior of cisterns, in order to see that impurities are not collecting, that no leaks exist, and that the overflow-pipes are properly arranged. A leaky condition of a cistern may lead to contamination of the water by influx of deleterious matter from the soil, aided by a favorable state of the surface of the ground. Rain-water may take up lead from the lining of the cistern and from lead pipes, and zinc from zinc roofs.

The situation and construction of wells, with reference to their liability to contamination from surface washings, oozings from drains or cesspools, and other sources of filth, will require the most careful investigation. Whenever cesspools or drains, whether open or closed, or accumulations of filth, are near a well and the soil about it is wet and filth-sodden, there will be a presumption of contamination. When suspicions arise, samples of the water should be taken for examination. Under certain circumstances, however, the evidence may be such as to warrant the closing, cleansing, or repairing of wells without resort to proof of impurity by chemical examination. When well-water is used it is advisable to inquire into the condition of the soil, which more or less influences the quality of the ground-water from which shallow wells are supplied. In districts where the soil is made use of as a reservoir for excremental matters deposited in cesspools and privy-vaults, or is exposed to defilement by leakage from disjointed or broken drains, badly constructed sewers, or leaky gas mains, or where filth is stored upon the surface of the ground, the entire water-bearing stratum in time becomes polluted, and the water of wells is rendered impure. On this account surface and shallow-well waters in thickly populated places are always to be regarded with the greatest suspicion. Shallow wells, even in rural districts, are often horribly polluted by sewage, and by animal matters of the most disgusting origin.

Public drinking-fountains should not escape notice, as they are sometimes improperly arranged, as, for example, in connection with drinking-troughs for horses. Cisterns for the public supply of ice-water may be permitted to become unclean by the accumulation of deposits, or the water may be rendered unwholesome by the injudicious use of impure ice.

Public baths should be kept under strict sanitary supervision. Not only should the supply of water be maintained in a fresh condition, but the regulations prescribing the proper use of the baths should be rigorously enforced.

Sanitary Inspection of Drainage and Sewerage.—The drainage and sewerage of a town bear important relations to the public health, and therefore properly come under the notice of the sanitary inspector. Nuisances arising from insufficient surface drainage, from dampness of the sites of habitations, and from badly planned and managed sewerage-works, frequently engage the attention of the health officials. It may not devolve upon these officers to suggest special schemes for the construction and improvement of public works, but it is a part of their duties to notice gross defects so far as they tend to exert an injurious influence upon the public health, and to urge the adoption of means for their remedy.

It may be necessary in some localities to have a system of deep drainage to facilitate the movement of the ground-water, and thus make both air and ground drier. A moist soil exerts an injurious influence upon health, it having been shown upon reliable evidence to be favorable to the production of lung diseases, rheumatic and catarrhal affections, and to be connected in some way with the development of typhoid fever and cholera. The drainage of swamps, areas of made-land, and places saturated with water, near or in inhabited districts, will be followed by the best results to the public health.

Surface drainage should be free and unobstructed, so as to promptly carry off the greatest amount of rainfall, and prevent the overflow of cellars or the intrusion of soil-water.

Nuisances are often caused by the disposal of slop-waters upon the surface of the ground or by wayside channels. Slop-waters or house-waters are in fact a condensed form of sewage, as they contain not only the cooking-water and water used for washing the person, clothing, and house, but almost invariably some portion of urine. Such matter is not fit to be discharged over the surface of the ground, as it must of necessity become offensive and cause a nuisance by decomposition and

soakage into the soil. If it cannot be disposed of upon the premises, it must be carried from the house in pipes to a proper outfall.

Sooner or later, every town must be provided with a system of sewers to prevent the collection of filth in and about habitations and frequented places, and to protect the air and soil from pollution. While aiming to carry out this object, the sewers themselves must not be permitted to become reservoirs of filth, which, by stagnation and decomposition, may give rise to a nuisance only less offensive and dangerous than that which it is intended to prevent. It is essential that sewers shall be well constructed and permit of a rapid, continuous, and complete flow of the sewage to the outfall without leakage by the way. They should allow no deposit to take place, and should be thoroughly ventilated. With these conditions maintained, it is scarcely possible for a sewer to become offensive or in any way dangerous to the public health. Ventilation may be effected by having numerous openings into the streets, protected by gratings, and by leaving the sewer-inlets untrapped. In this way a free interchange between the sewer-air and the atmosphere is secured. The openings will relieve pressure upon the house-drains, and if these latter should be left unguarded the danger from the admission of sewer-air will be greatly diminished by the free dilution of the latter with atmospheric air.

The escape of evil odors from untrapped sewer-inlets is not a valid objection to the disuse of the trap, but rather an indication that the sewer does not properly perform its mission, which should lead to the remedy of the fault and not to its concealment. With the conditions giving rise to the nuisance unremedied, it is far safer to permit the escape of sewer-air upon the streets than to subject the inhabitants of houses having connection with the sewer to risk by closing the manholes and using traps upon the inlets, and thus increasing pressure and preventing the diluting effect of the outside air.

Extrinsic flushing will be required when the force of the current of sewage is not sufficient to produce a scouring effect. The cleansing and disinfection of sewers are occasionally required to improve their condition, but at best they are only temporary expedients. Sewers which accumulate deposits and are commonly foul, and which constantly require cleaning out and disinfection, are radically wrong in construction and should be reconstructed without delay.

When sewers are properly constructed and managed and have free ventilation, the air which they contain differs but slightly from the outside air; but as these conditions cannot always be insured, it is a wise plan to have the house-drain disconnected from the sewer by means of an efficient trap, and the system of house-pipes thoroughly ventilated. The disposal of sewage should take place without causing a nuisance in relation either to air or to water. This is a subject of serious consideration in the planning and management of the outfalls of sewers. The sewage of a town should never be discharged into a stream at or near a point from which the water-supply is obtained, or which, from its small volume of water, is incapable of diluting the liquid refuse sufficiently to prevent serious pollution, without first undergoing a proper degree of purification. Purification of sewer-water may be effected by precipitation at the outfall by chemical agents, by irrigation, and by intermittent filtration. If properly managed, any one of these methods may be applied with satisfactory results.

In small towns and villages it may not be practicable to provide a general system of sewers, and hence the disposal of refuse matters, such as excreta and house-waters, must be effected by other methods. As the choice of these plans is more or less directly under the control of the householder, being only exceptionally restricted by local regulations, a variety of methods will be encountered in every locality, including even the large cities. For the disposal of excreta the cesspool or privy-vault, or some one of the dry methods, is resorted to; but the house-slops are not so readily gotten rid of. In towns the open gutter is commonly used for this object, while in villages and in the country the slops are thrown upon the ground. These plans for disposing of refuse matters are everywhere among the chief sources of nuisances, and will constantly claim the attention of the inspector.

Privies of the accumulative sort, with their respective soakings and exhalations, whereby air, soil, and water are polluted, are a very common means of spreading some of the most fatal of diseases, of which typhoid fever may be taken as a type. The utmost watchfulness should be exercised to reduce these nuisances, which exist in all populous places throughout the country, to the lowest degree of dangerousness. Privy-pits and cesspools, if at all permitted, should be made to conform to the most stringent regulations both as to their construction and management. They should not be located too near the house or the water-well; they should be constructed of unabsorbent materials, and should be perfectly water-tight, so as to prevent the leakage of filth into the soil, building, or water; they should be of small capacity, so as to preclude the accumulation of matter, and they should be regularly and methodically cleaned at short intervals, so as not to allow the putrefaction of excrement. Their use should not be permitted for anything but excreta.

To meet sanitary requirements, improved systems have been devised to take the place of the filthy storage-pits, so universally condemned. These are principally the pail-system and the so-called dry systems. The simple pail-system, much used in England, but not yet systematically adopted in the United States, consists in the removal of excremental matter at short intervals, before it has become offensive. As a means to this end, movable receptacles are used which systematically, at short intervals, are to be changed, clean for the dirty, by the scavenger; and which, in order to prevent offence in this process, are provided with tight-fitting lids to be applied to the foul pails under removal. The excrement is removed daily without admixture, except with the ordinary kitchen refuse, and is transported outside the town.

The dry system is adapted to towns and villages and to single cottages. It consists in the admixture of dried earth, coal ashes, or other dried refuse, with the excrement in sufficient quantity to absorb and reduce it to an inodorous form. All slops and sink-water and other extraneous matter must be carefully excluded. The receptacles should be made of impervious materials, and the closet should be located either out-of-doors, or in an isolated part of the building, or in an apartment projecting from the house, where the necessary ventilation can be secured. The dry systems form a convenient, economical, and efficient substitute for water-closets where the latter cannot be made use of, but they must be vigilantly superintended, and in some cases actually managed by the local authority.

It is essential that privies of all kinds, particularly those located in poor neighborhoods, shall be under constant supervision, in order to prevent the violation of the laws and regulations pertaining to their construction and management. But this supervision should not be confined to the privy contrivances and the methods of their cleansing, but should also extend to the ultimate disposal of the matter, which is a most important part of the management of refuse removal.

Nuisances incident to the improper disposal of liquid house-wastes are of frequent occurrence. In towns and villages, the house-slops are either thrown upon the ground near the house, where they are partly absorbed and in time load the soil with impurities; or they are carried away in open or in closed channels to some distant part of the premises, where they gradually soak into the ground; or they are discharged into the roadside or street-gutter, causing a nuisance of a most offensive character. Sometimes the entire sewage of the house is collected in cesspools provided with porous walls, with the object of allowing the fluid parts to drain away, the solid matter being removed only after long accumulation. In the absence of sewers, these nuisances may be avoided by providing tight cesspools with sufficient capacity for one or two days' collection, from which the sewage may

be distributed to the land near by through pipes under the surface of the ground. This is the plan of subirrigation, which is very convenient for the disposal of the sewage of separate houses or groups of houses, where land is available.

Subsurface irrigation may be used for the disposal of slops alone, or for slops mixed with the efflux of water-closets. It is necessary, however, to provide a means for intercepting all solid and fatty matters, which should not be discharged into the drain-tiles, as they would in time clog up the pipes and render the system inoperative. Solid excrement may be disposed of in a cleanly and inodorous manner by the use of the earth-closet, only the slop-water being allowed to flow away in the subsoil drains.

The success of this plan depends on the property of the soil of destroying organic matter, by the aid of the oxygen contained in its pores, and, to some extent, upon the action of the rootlets of grass and plants. The supply must be intermittent, and in order to secure this action a flush-tank is provided, which automatically discharges its contents through all the ramifications of the drain-tiles. When water-closet wastes are disposed of at the same time, an intercepting chamber should be placed between the house and the tank to collect the solid matter, which should be removed at frequent intervals and applied to the land.

The occupants of rural premises will generally be able to satisfactorily dispose of their own refuse matters upon their own premises, without any detriment to themselves or to their neighbors. But when human beings are gathered together on small areas, the disposal of refuse cannot be secured without method. The obligation to designate the correct system of disposal and to supervise its management, so that no avoidable nuisance shall be created, rests upon the sanitary authority.

Frequent inspections will be required in order to prevent nuisances from arising through neglect in the disposal of dry house-refuse, such as ashes, dust, and garbage, and through improper disposal of trade-refuse and the refuse of domestic animals. Provision must be made for the frequent and regular removal of these matters, and, at the same time, regulations must be enforced which shall prescribe that house-refuse, while awaiting removal, shall be so cared for and managed as not to cause a nuisance on the premises. Every facility should be afforded the householder for promptly getting rid of his refuse, so that no excuse can be offered for the accumulation of offensive matters upon his premises.

Faults in house-drainage and plumbing are a frequent and formidable danger to the public health. Until within recent years, this fact has been very imperfectly recognized by architects and builders, and by the public generally, and too much trust has been placed in artisans, who have been permitted to proceed in their work without any carefully wrought plan or expert supervision, and also without their qualifications first having been thoroughly ascertained. As a result of various deficiencies, and prominently that of neglect of competent sanitary supervision, it frequently happens that the evils a modern system of house-drainage is intended to avert, are made worse by careless planning and execution of the drainage arrangements within the dwelling. Owing to the absence of skilled guidance, and frequently through want of conscientious execution, defects in house-drainage of the most flagrant character are constantly encountered, even in the better class of houses. But a greater familiarity on the part of the public with the correct principles of house-drainage, and supervision of the work by boards of health, will tend to lessen abuses, which are responsible for a large quantity of preventable disease. In many places laws regulating house-drainage have been enacted, and entrusted for their execution to the local sanitary authority. Under these laws, rules and regulations are prescribed for the registration of plumbers and for the guidance of artisans in drawing their plans and specifications. In large cities the plans, when approved, are executed under the supervision of trained officers especially appointed for the purpose; but in small towns the work of supervision may be advantageously combined with the duties of general sanitary inspector. The laws and regulations in force in Boston, New York, Philadelphia, and Washington may be cited as examples of the methods adopted for conducting this important branch of house sanitation. The object of these laws is to place the drainage arrangements of houses under skilled surveillance, so that their planning, construction, and management shall conform to standard principles.

The essential conditions of house-drainage are: That the receptacles shall be constructed of such material and in such manner as to be impervious to fluids, and easily permit of cleansing and of being kept clean in all their parts. That the pipes and drains shall be of sound and durable material, and so constructed and laid as to be gas-tight throughout, and to secure a continuous and complete removal of whatever enters them without leakage by the way, or without the formation of deposits or incrustations. That the system shall be so planned and arranged that neither the air of the house nor the drinking-water can in any wise be polluted by the escape into the house of air from the sewer or from the drain. Upon these fundamental principles are based the rules and regulations governing the technics of construction, which should be formulated for the guidance of the architect, builder, and artisan. The law should require that the plans and specifications of the drainage arrangements of every proposed dwelling, and of old houses undergoing alterations, should be submitted for approval to a competent official or board of experts, and that the essential details of such plans should be carried out under skilled supervision. The effect of such a requirement would be to avoid errors in design and construction in new buildings, and to gradually improve the drainage arrangements of old structures.

As the best systems of house-drainage are liable to derangement which may escape the notice of the householder, provision should also be made for the periodical inspection of the drainage-works of every dwelling, in order to guard the occupants against the evil consequences of deficiencies of which they may have no knowledge.

In many places no systematic regulation and supervision of house-drainage is ever attempted, the authorities having to depend for knowledge of existing defects upon complaints made in special cases, upon the results of investigation of the localized causes of disease, or upon discoveries made during a casual house-inspection. This information relates to a small number of the actual defects, the greater number escaping detection in the absence of methodical inquiry. Where no such laws exist, the sanitary authorities may do much toward effecting a reform in the present objectionable methods by adopting and promulgating regulations similar to those in force in the cities already mentioned, for public information, for the instruction of their inspectors, and to serve as a guide in all work which they are called upon to perform. Thousands of houses are annually built in a manner dangerous to the health of the occupants, because the builders are ignorant of the conditions to be observed to make them healthy, and they fall into the errors which might have been avoided had they the knowledge of the correct principles of construction, or had the authorities required their application.

Sanitary Inspection of Public Ways and Places.—The sanitary importance of thorough cleanliness of public ways and places cannot be over-estimated. The deposit and retention of refuse matters upon the surface of streets may give rise to dangerous pollution of air and soil. This is apparent when the composition of the filth of badly-kept streets is inquired into. In addition to the inorganic detritus of the road, it consists of the dung and urine of horses, and sometimes of other animals, of vegetable matter from trees, of refuse from houses—kitchen garbage and house-slops—containing animal and vegetable matter, and, in poor neighborhoods, there is sometimes an admixture of human excrement, both solid and liquid. This mixture of animal and vegetable substances, when converted into dust, fills the atmosphere

with disgusting particles, or when wetted by rain and exposed to heat, soon decomposes and develops effluvia which must be detrimental to health, especially in crowded and ill-ventilated localities. Unless the pavement is composed of impervious materials, liquid matters upon its surface will penetrate into and pollute the soil. These results are due to imperfect drainage, to a bad system of scavenging and refuse-removal, and very materially to badly constructed pavements.

Surface cleansing cannot be made efficient without the provision of suitable pavements—such as will prevent the retention of filth and its imbibition by the soil. It is especially important that this provision should be extended to all small streets, courts, and alleyways, and to the surface areas in all crowded and badly ventilated places, as in such localities the open spaces are likely to be used as common depositories for all kinds of refuse matter, including human excrement.

The construction of public roadways and the conservancy of the surface area of towns are commonly entrusted to a commission or board of public works, but the delegation of these powers to a co-ordinate branch of government does not relieve the sanitary authorities of the duty of closely scrutinizing the work, and noting deficiencies which tend to injure the public health, and of urging the proper remedies.

Under certain circumstances the application of disinfectants to the street surface and gutters will be required, but this precaution will rarely be necessary when proper care is exercised in the construction and cleansing of the pavements. The utmost care will be required in preventing public urinals from becoming nuisances of an offensive character. These conveniences should be washed out daily, and otherwise carefully managed under the vigilant eye of an inspector.

The relation of gas and lighting to the public health is a subject demanding careful investigation. Adequate lighting of the public streets and places is not only essential to public convenience and order, but is a means of restraining the perpetrating of nuisances which are apt to be committed under the protection of darkness. Gas should be maintained of a specific illuminating power and purity. Impurities in gas not only diminish its illuminating power, but tend to injure health by deteriorating the air in the rooms where it is used. The escape of gas from defective joints, or from flaws in the street pipes, has often been attended with disastrous results. The escaping gas may pass through the foundations of houses and poison the air within. This accident is not uncommon in the winter season, when the air in the ground surrounding the house is apt to be drawn into the basement by the aspirating power of the heated air within the building. Gas may also prove injurious by fouling the water of wells. Another danger is from explosion in sewers, and in cellars and cesspools connected with sewers by drains, the gas escaping into the sewers and thence being conveyed upon private premises through badly constructed house-drains and untrapped inlets.

The location of gas-works, with respect to the influence on the health of the neighborhood of vapors escaping during the process of gas-production, and also with respect to the manner of disposal of refuse matters from gas-working, will occasionally require a careful investigation.

The sale of illuminating oils should be restricted to such qualities as are known to be free from explosiveness. The law should make provision for ascertaining the grade of petroleum exposed for sale, and should prohibit the sale of this article at retail when its "flashing-point" is below 100° F. The routine work of testing oils and burning fluids is properly delegated to special officers, but the sanitary government should interest itself in procuring the adoption of laws which will avert accidents and prevent the loss of life.

Sanitary Inspection of Slaughter-houses and Abattoirs.—By mismanagement slaughter-houses may become a nuisance to the neighborhood, or their condition may be such as to affect the wholesomeness of the meat prepared for the market. Wherever located these establishments will always require careful supervision, as from the nature of the business nuisances are readily created by putrescent effluvia, or by filthy soakage or outflow. Particular attention should be directed to the location and construction of the buildings, to the means of water-supply, drainage, and ventilation, to the provision of suitable receptacles for the refuse and its prompt removal, to the means of preventing filthy soakage of liquid refuse within or about the buildings, and to the maintenance of cleanliness throughout the establishment and in every process of the business. By-laws prescribing rules embodying these essential points should be adopted, and their observance enforced by vigilant inspection.

Slaughtering is most commonly done in private establishments, which are seldom constructed, equipped, or managed in strict conformity to sanitary principles. Many of these establishments are extemporized out of buildings constructed for other purposes, and are totally unsuited for the slaughtering of cattle. As they are generally located in densely populated parts of the town, their deficiencies and mismanagement have the widest scope for exerting a pernicious influence. By placing these establishments under the control of the board of health, and requiring a permit to engage in the business, conditioned upon proper location and construction of buildings and good management, a great reform can be effected in a business which is too often conducted in a slovenly manner, to the detriment of the public health.

The concentration of the business of slaughtering cattle in well-appointed and well-conducted public slaughter-houses, or abattoirs, where abundant water, good drainage, thorough ventilation, ample means of cleanliness, and perfect facilities for the work are provided, and where every branch of the business is conducted under constant official observation, is strongly to be advised, as a measure highly advantageous in its economic and hygienic results. The adoption of this practice is gradually being extended as its benefits become understood and appreciated.

The fact that typhoid fever, scarlet fever, and some other diseases have been spread through the agency of milk, makes it imperative that cow-houses, dairies, and milk dépôts should be managed under the provisions of salutary laws and systematically inspected, in order to insure the enforcement of such provisions.

Sanitary Inspection of Markets.—All markets should be placed under the control of the sanitary government. The construction and management of the buildings should be such as to insure ample light, free ventilation, perfect drainage, prompt removal of refuse matters, and thorough cleanliness. Supervision should also be extended to the immediate neighborhood, including the streets and passage-ways, with the view of preventing any avoidable nuisance. The provision of smooth and impervious pavements is necessary, in order to facilitate cleansing and prevent the retention and imbibition of filth.

Sanitary Inspection of Food Supplies.—The supervision of the food supplies of the people is one of the most important obligations of a municipality. While the price and the quality, in a measure, must be left to the ordinary operations of trade, the law must take cognizance of and prevent adulterations, and the manufacture and sale of any articles intended for human consumption that are injurious to health. In order to effect this object the law should clearly define the offence of adulteration in all its various forms, and also designate the kind of food which is unwholesome and the circumstances which render it so, and direct the course to be pursued in condemning, and withdrawing from the market, and disposing of, any diseased, or unsound, or unwholesome food, or food unfit for the use of man. It should also embrace provisions for its own thorough and complete execution.

The organization necessary for carrying into effect such regulations, as well as many other important measures connected with the preservation of the public health, already exists in many States in the form of a State board of health. Vesting such authority in a central board

should not abrogate nor conflict with the regulations of local boards for the inspection of food-supplies, such as meat, fish, game, vegetables, and other perishable articles which require daily supervision; but, on the contrary, would furnish a means of co-operation in effecting a common purpose.

While the main object of legislation against adulteration is the protection of the public health, it yields a further advantage by its economic results. This fact is prominently displayed under the operations of the Massachusetts food-inspection law. Of articles liable to adulteration, such as milk, butter, spices, vinegar, cream of tartar, and some drugs, consumed in that State in 1884, of the value of $15,000,000, five per cent., or $750,000 were saved to consumers through the services of inspectors of food.

Most European countries are well provided with laws, both general and municipal, for regulating the manufacture and sale of articles of food, but, beyond enacting a law prohibiting the importation of damaged and adulterated tea, and regulating the sale of oleomargarine, the United States Government has done little to insure the purity of food. Most of the States have statutes relating to special articles of food, some of which have a purely commercial object, while others are intended for the protection of the public health. Massachusetts, New York, and New Jersey have recently adopted stringent measures for the prevention of the sophistication of food and drugs, which have already been productive of good results. These laws have been ingrafted upon those of the State boards of health. One of their objects is the protection of trade by preventing falsifications which may or may not be injurious to health; but the vital purpose is to take cognizance of adulterations which are deleterious, and to prevent the sale of such articles of food.

Violations of the law are detected by the employment of inspectors and analysts, and its provisions enforced by notification and warnings, or by prosecution and penalties, and in some cases by the confiscation of condemned articles. The same officer may act in the dual capacity of inspector and analyst.

In order to promote the objects of food-inspection public test-offices, properly equipped with all necessary appliances, should be opened for the examination of all articles submitted by the inspectors, and also by the people. Such an office has been established in Paris, where all articles of food, beverages, etc., are analyzed and tested by experts, who also perform the duties of inspectors of markets and among the tradesmen. For a nominal sum, and in some cases gratuitously, anyone can ascertain the composition of any suspected article of food. Articles of domestic use, clothing, colored toys, wall-papers, etc., are also examined in order to detect any poisonous ingredients that may be present.

Adulteration has been practised in a great variety of foods, beverages, and drugs; but the practice is commonly restricted to a limited number of articles. The principal articles liable to adulteration are milk, butter, cheese, spices, vinegar, sugar, ground coffee, tea, oils for consumption, cream of tartar, spirits, and various sorts of drugs, and to these special attention should be directed.

The examination of meats, fruits, and vegetables, and other perishable articles, should be made with great frequency, as the stock is ever changing.

Animals should be examined immediately before killing, and again before the meat is exposed for sale. The concentration of the business of slaughtering in public slaughter-houses or abattoirs will make efficient inspection practicable.

In order to facilitate the labors of the inspector, the law should describe the kind of food which is unwholesome, or the circumstances which render it so; but with the best care as to details, much will have to be left to the discretion of the officer who makes the examination. Study and practice will enable him to successfully discriminate in most cases coming under his observation. Occasionally it will be necessary to refer suspicious articles to the public analyst for the application of chemical or microscopical tests.

It is the practice, in the city of London, to condemn the flesh of animals infected with certain parasites, as *trichina* in pork, the *cysticerci* in pork, beef, and mutton, and *flukes*, which infest the livers of animals; and of animals suffering from fever or acute inflammatory diseases, as rinderpest, pleuro-pneumonia, and the fever of parturition; and of animals wasted by lingering sickness, such as phthisis; and of animals which have died from accident or from natural causes; and also all meat that is tainted with physic, or that is sufficiently decomposed to be discolored or have a putrid smell.

The flesh of animals which have been exhausted, excited, or tortured before death, has frequently proved to be unwholesome.

Sausages are liable to become poisonous on account of a modified putrefaction which occurs in this variety of food when kept for a length of time. The poisonous effects have generally been traced to sausages which are mouldy and soft in the interior, and which emit a strong-smelling odor. Other kinds of animal food, when in a decayed or mouldy condition, may occasionally produce similar results.

Fish, poultry, and game must be examined for signs of decomposition.

Fruit and vegetables must be objected to mainly on account of advanced decomposition. Mouldy food of all kinds is dangerous, and should be condemned.

The testing of canned goods for poisonous substances, and the examination of milk, butter, cheese, coffee, tea, sugar, cocoa, flour, bread, vinegar, drugs, etc., is mostly work to be performed in the laboratory, the duty of the inspector being chiefly confined to procuring samples of suspected articles for analysis.

The officers selected for the responsible service of food-inspection should possess special attainments and undoubted honesty, and in order to secure proficiency they should be required to devote their entire time and energies to the work.

Sanitary Inspection of Manufactures and Trades.—Noxious or offensive trades and manufactures require supervision in order to protect the health of employees and prevent the processes from becoming a nuisance, or injurious to the health both of the work-people and the public generally. The law should not only make it imperative that the ordinary conditions of health shall be observed; it should go a step further, and restrict labor at certain ages, and regulate the hours of work.

The workshops should be well lighted, thoroughly ventilated, and, when necessary, provision should be made for the prompt removal of dust-particles. The speedy removal of deleterious refuse matters and the observance of extreme cleanliness should be enjoined, and all overcrowding prevented.

Trades which produce offensive effluvia, dust, or acrid vapors, are apt to cause nuisances which are injurious to health, or which may simply annoy or inconvenience the public. Nuisances of the latter description are subjects for action at common law. When the public health is imperilled the sanitary authorities are bound to interfere.

The workers at certain trades are liable to suffer in their health from the inhalation of solid or gaseous substances produced by the processes, unless efficient safeguards are provided. The dust in cotton and woollen mills, metallic vapors, filings and grindings, and solid particles of various kinds, when inhaled, are highly injurious. Certain gases and fumes and fetid substances also have an injurious effect, if breathed in confined apartments.

The public also are to be protected from annoyance and from injury to health resulting from the improper conduct of dangerous, noxious, or offensive trades. The businesses apt to create nuisances are very numerous, as will be seen by a reference to the classification adopted by the French Government in 1866, which may be profitably consulted. It is not expected that the inspector shall be familiar with all the details of the various trades therein specified, but he should have a general knowledge of the sources and effects of the offensive effluvia and outflow produced by certain well-known processes of

manufacture, so that when complaint is made he will be able to intelligently investigate these offences and suggest the best means for their remedy. To perform this oftentimes perplexing duty it is necessary that the inspector shall possess good powers of observation, a thorough acquaintance with practical chemistry, and familiarity and experimental knowledge with regard to the uses of various mechanical contrivances and the modes of testing their efficiency. It is only by close personal observation and careful investigation that reliable information can be obtained upon which to base the suggestions of remedies. Suggestions should not be made without extreme caution, and in no case unless there is a strong probability of a successful result. In some few special cases it may be necessary to employ the services of an expert who has greater familiarity with the questions at issue.

With proper precautions, offensive trades and manufactures can be conducted without causing a nuisance. Whenever advantageous and practicable, foul refuse matters should be utilized; but if this cannot be done, other means should be employed for their disposal without causing a nuisance by contaminating either air, soil, or water. Foul matters awaiting disposal should be stored in closed tanks or receptacles. Suitable receptacles with tightly-fitting covers should also be used for removing such matters. Dangerous or offensive gases or vapors should be intercepted and rendered harmless and inoffensive by the use of proper condensers, or scrubbers, or of absorbents, or by combustion in the furnace-fires. A combination of these various means may often be advantageously adopted. All offensive processes, such as fat-rendering, bone-boiling, etc., should be conducted in steam-tight tanks, and the vapors given off should be passed through condensers, and such fetid matters as may not be removed should be consumed in the furnace-fires.

The inspection of mines, and the storage and sale of explosive and poisonous substances, etc., are generally regulated by State laws, and do not require the special attention of the sanitary inspector.

Sanitary Inspection of Public Schools.—The sanitary supervision of schools is an essential part of the administration of every well-ordered system of public education. The object of such supervision is the protection and preservation of the health of the children by securing proper sanitary arrangements of the school buildings, the observance of the laws of health, the enforcement of regulations for the prevention of the spread of contagious or infectious diseases, and by practical instruction in the plain rules of hygiene.

The surroundings in which the child passes the first years of its life should conduce to its healthy development and not impede it, as is so often the case in a large number of our schools. The aim of modern education should be to foster the physical as well as the intellectual and moral development of the child, not only for the advantages of health itself, but also for the sake of establishing a sound physical basis, without which true progress in the culture of the intellect is impeded or prevented.

When the State assumes the responsibility of educating the children, it also obligates itself to carefully guard their health, both physical and mental. This obligation is due to the public who entrust the care and training of their children to others during a large portion of their lives. The State should not be content simply to "hold physical childhood unharmed while mental childhood is getting its schooling;" it should strive to promote physical health and vigor as an indispensable accompaniment to intellectual training, in order to make public education an important measure of public economy as well as a powerful moral agency.

As a means of promoting these objects, the aid of sanitary and medical science must be invoked in the adaptation of the school buildings for healthful occupancy, in supervising the hygiene of the premises and the hygienic care of the children, in preventing the spread of contagious or infectious diseases, in regulating the programme of studies, and in imparting practical notions of hygiene and sanitary law.

The selection of the site, the construction, heating, lighting, ventilation, water-supply, and drainage of the school buildings, and the details of arrangement and management of the buildings and appurtenances, must be in conformity with the principles of sanitary science. The arrangement and adaptation of light and of the school desks and seats, according to the requirements of hygiene and the special needs of the children, are most important considerations. Mental application should be carefully proportioned to the capacity of the child; it should be neither too taxing nor too prolonged, and should be alternated with recesses and physical exercise in the fresh air.

The best-constructed buildings may be rendered unhealthy, and the most perfect sanitary appliances and arrangements may become inoperative, by the neglect of those in charge. Hence it is necessary that the sanitary supervision of the buildings and appurtenances shall be entrusted to qualified officers, who shall be responsible for everything pertaining to the hygienic management of the institutions.

Sanitary supervision is an effectual means of preventing the spread of contagious diseases in, and by means of, schools. The medical inspector, aided by the teachers (who should be instructed how to recognize the premonitory symptoms of contagious diseases), will take advantage of early information of the appearance of suspicious symptoms in any child, by sending the child home at once for his further observation, and treatment if necessary. If the disease be infectious, any other children in the family, though well, must not be permitted to attend school until the cure is complete and all danger from infection has passed.

No child should be allowed to enter the public schools who has not been vaccinated. The medical inspector should determine the evidence of satisfactory vaccination.

A close observation of the children will enable the inspector to determine whether any injury to health is liable to happen, by reason of constitutional disease or weakness, from the course of study or discipline, and advise such modification as the case may require. Children predisposed to consumption, scrofula, lymphatic disease, anæmia, etc., should be the objects of the greatest solicitude of both teacher and physician while under their care.

Besides the provision of favorable surroundings, fresh air, light, proper temperature, etc., special attention should be given to the personal hygiene of the children, to their clothing, proper cleanliness, exercise, and the regulation of studies, so as not to overtax and fatigue the organs of the child.

The medical inspector should have a ready faculty for teaching, as his position will enable him to speak with authority and effect, and to utilize the many opportunities afforded for instructing the children in the elementary principles of hygiene, by means of examples coming under their own personal observation. He should describe to them the dangers from the use of alcoholic drinks and tobacco, the ill effects of want of ventilation and uncleanliness, the reasons for isolating infectious diseases and for the practice of vaccination, the improper use of clothing, either too warm or too thin, the effects of improper attitudes, the causes of near-sightedness, etc. Occasional instruction of this kind will be most serviceable in impressing the lessons in hygiene which should form a part of the regular course of instruction, and in diffusing throughout the community a knowledge of sanitary laws.

Systematic records should be kept, with the use of suitable blanks, of the results of medical inspection, which should be summarized and presented, with deductions and recommendations, monthly or oftener, if necessary, to the board of health or the body having sanitary jurisdiction over the schools, and to the superintendent of public instruction. These blanks will provide for a complete descriptive list, including medical observations

of each pupil who enters the school, upon which list entries may be made from time to time, at least once in each year. There should also be kept a record of diseases, accidents, and indisposition occurring at school during the month, with particular notice of cases of contagious diseases, and statistical information with regard to the premises, embracing notes on the cleanliness of rooms, school furniture, heating and ventilation, thermometric records, lighting, condition of water-closets, urinals, yards, dressing-rooms, etc. Reports should also be made of sanitation and hygienic improvements proposed, and of the matters of personal hygiene which have been the subjects of familiar instruction.

A most complete system of medical inspection of public schools was inaugurated in the city of Brussels, Belgium, in 1874, and has been in successful operation ever since. The thirty-three public schools of that city are subject to regular medical inspection, performed by five medical officers, who devote their whole time to this work. They have the entire sanitary supervision of the schools and buildings, and the watchcare over the health of the children, and, under special circumstances, the treatment of cases of sickness.

The service includes within its scope a consideration of faults in construction, heating, ventilation, lighting, size of class-rooms, seats, desks, windows, etc.; the temperature and daily condition of the air and the causes tending to vitiate it; physical exercise, swimming lessons, and instructive excursions; the care of the eyes, ears, teeth, skin, and body; accurate records of conditions of health determined by physical examination, and the adaptation of studies and discipline to the capacity of the child; careful training of children under the normal standard of health, and measures for preventing the spread of contagious or infectious diseases, including vaccination and revaccination; and proper sanitary instruction, so that the schools shall be the means of diffusing among the people a knowledge of the laws of health.

Sanitary Inspection of Hospitals and Public Charities.—The government of hospitals and public charities is generally entrusted to boards of directors, variously constituted, which are responsible for its proper administration. Efficient sanitary management is a primary consideration, and in securing this object valuable aid is derived from the counsel of the medical officers, who, by education and special facilities for observation, know best the wants, the necessities, and the failings of the institutions with which they are connected, and are therefore competent to speak with authoritative advice on questions pertaining to their sanitation.

Independent of these provisions for responsible government, the State or local authority should have the assurance of the faithful and efficient administration of its delegated powers which periodical investigations will afford, and, among other things, should take cognizance of the sanitary condition of these institutions, either through the State or local health boards, according as they fall under the jurisdiction of the one or the other.

Sanitary inspections should be made periodically, and the results recorded for future reference and use. The primary surveys will necessarily embrace a large number of inquiries, many of which, if satisfactorily answered, need not be made again; the subsequent inspections being confined to conditions liable to variation, and which depend on various contingencies. Much of the information required, such as details of construction, cubic air-space, plans of drainage, ventilation and heating, statistical data, etc., will be available from reliable records preserved by the institutions, so that the inquiries will be directed more especially to the adaptation of the buildings to their uses, the efficiency of the sanitary arrangements, the salubrity of locality, the sanitary condition and management of the buildings and premises, and the management of contagious diseases.

The special points to be inquired into are: The location, nature of the soil, area of grounds, drainage arrangements, materials of construction of buildings, number of stories, floor plans, number and size of wards, floor-room per bed in wards, cubic space per bed, mode of heating and ventilation, position of water-closets, urinals, etc., and their ventilation, provisions against fire, fire-escapes, amount and quality of food, water-supply, overcrowding, prevalence of hospital zymotic diseases, as erysipelas, pyæmia, etc., contagious diseases and their management, disinfection, presence of endemic influence, hygiene of the buildings and premises, and rules, regulations, and statistics on sanitary subjects.

The results of inspection should be recorded in proper form for use in furthering the ultimate objects of the investigation.

Sanitary Inspection of Police and Prisons.—Oversight in all matters of concern to health in these departments should be exercised by the proper sanitary authorities. The station-houses of the police department will require occasional inspection, in order to insure the application of necessary hygienic measures. The buildings should be expressly adapted to their uses, and all necessary appointments should be made for the health and comfort of the officers, and for the decency, convenience, and cleanliness of the prisoners. The air-space per head for the average occupancy of the cells should conform to a standard. Special attention should be given to the ventilation, heating, privy arrangements, and cleanliness of the cells, and also to the facilities for personal cleanliness.

Arrangements should be made for prompt surgical and medical attendance, at all hours, upon cases of injury or sickness, and for the immediate examination of suspected cases of contagious or infectious diseases brought in from the street, so that persons suffering from dangerous communicable diseases may be transferred to the proper hospital, and the cleansing, disinfection, and fumigation of the apartments executed with despatch.

An ambulance system in connection with the police department, for conveying the sick and injured to hospital should be organized and conducted under medical supervision. The regular and systematic instruction of the police force in the manner of rendering first aid to the sick and wounded is a humane requirement, which should be carried out under competent medical direction.

The sanitary inspection of prisons should be carried out upon the general plan suggested for hospitals and public charities. Special attention should be directed to the cubic air-space per head of occupancy of the cells, to the ventilation, heating, and privy arrangements of the apartments, to the cleanliness of the prisoners, and to the means at hand for checking the spread of contagious diseases. Every well-ordered prison should have an isolated building or apartment for the treatment of these diseases, to which all cases at their inception should be removed, if they cannot be at once transferred to the town hospital for contagious or infectious diseases.

The medical inspection of houses of prostitution, in aid of the suppression of one of the worst forms of human disease, must be conducted under the provisions of special laws upon the subject.

Sanitary Inspection of Fire Establishments.—Fire establishments should be included among the institutions subjected to sanitary supervision. The hygienic condition of the premises, water-closet accommodations, facilities for bathing, and the manner of berthing and subsisting of the men are the chief points of inquiry.

Medical attendance should be provided for the sick and disabled. Suitable apparatus for the rescue of life endangered by fire should be distributed over the town, and be under the immediate control of the fire or police department. The inquiry should also be extended to the provisions made for the erection of fire-escapes, and for the inspection of illuminating oils, and the storage of explosives.

Sanitary Inspection of Cemeteries and Burial.—The disposal of the dead without injury to the living is a question of the greatest interest to a community. Cremation, a process by which bodies can be rapidly, completely, and inoffensively disposed of, solves the problem to the satisfaction of hygienic laws, but the

practice is in its incipiency. The common mode of burial by interment requires the strictest sanitary regulation. The location of burial-grounds should be determined only after the most careful inquiry into the sanitary features of the question, and a full consideration of the future, as well as the present, needs of the community. Intramural interment, being in conflict with the laws of health, should be interdicted.

In locating cemeteries the site, character of the soil, facilities for drainage, direction of the ground-water, and distance from inhabited places are prominent considerations. The site should be elevated, so as to afford good ventilation and ample drainage; and it should be well planted with shrubs and trees, in order that the roots may absorb and utilize the products of decomposition. The soil should be dry, and the ground-water never permitted to rise into the graves or vaults. When necessary, artificial drainage should be employed to prevent the accumulation of water in the soil. The drainage should not be allowed to flow into any water-course from which drinking-water is obtained; nor should the flow of the ground-water be toward inhabited places which depend on wells for their water-supply. When there is a choice, a loose, marly soil should be selected, as it permits of the free movement of air and water, conditions which are essential to speedy decomposition. Gravelly soils are not so good, but they are preferable to stiff clays, which tend to retard the process of decay.

The decomposition of bodies takes place by putrefaction with the evolution of effluvia. The products of decomposition are arrested or changed by the earth. Under certain conditions the volatile substances generated by putrefaction may escape into the air, and hence the air over graveyards is liable to contamination. Saponification may take place when the earth about bodies is dense, and becomes saturated with the products of decomposition.

The time required for the decay of bodies varies according to the nature of the soil, the access of air, pressure, etc. Ordinarily, in a loose, marly soil the process may be completed in three or four years, but in other soils of a less favorable character it may be very slow, thirty or more years being required for effecting a complete disintegration. Before interfering with an old graveyard a sufficient time should be allowed to elapse, after the discontinuance of all interments, to insure the complete destruction of the remains. Deep burial is to be preferred, and not more than one body should be placed in a single grave. The earth should come in contact with the coffin, in order to hasten decomposition. The use of strong outer cases is objectionable, as it prolongs the process of decay.

The vicinity of cemeteries is not considered salubrious, owing to the danger of contamination of the air and water, and the escape of effluvia from frequent disturbance of the soil saturated with the products of putrefaction. Most foreign governments prescribe the least distance allowable between graveyards and dwellings; but in the United States there is no general regulation on the subject. Under ordinary circumstances the distance should be at least five hundred feet.

It is customary among the poor to keep the bodies of their deceased friends for days in the same room in which the family live and sleep. Such a practice cannot be otherwise than detrimental to health. In order to avoid the necessity for such detention, mortuaries should be provided in every city and town, where, in these cases, all corpses could be removed at a reasonable time after death has taken place. Burial should not be delayed for more than three or four days, and in hot weather and in all cases of infectious disease the interment should promptly take place. Another advantage of mortuaries is the means they afford of lessening the expenses of the funeral, a point of great significance to those in humble life.

No interment should be permitted without a permit from the board of health, issued over a certificate of death from an authorized person; nor should any grave be disturbed, nor any body be removed into or out of any place, without official authorization.

Special care is required in the management of the bodies of those who have died of contagious or infectious diseases. In such cases public funerals should be absolutely prohibited, and the interment should take place without needless delay.

Vigilant inspection is essential to the efficient administration of the laws and regulations pertaining to cemeteries and burial. This duty may be imposed upon the sanitary inspector, or an officer specially appointed by the board of health, which body should have the power to make rules for the proper disposal of the dead.

Sanitary Inspection in Cases of Contagious or Infectious Diseases.—The prompt notification of cases of dangerous communicable disease is a duty generally imposed by law upon the medical attendant, and its neglect is made punishable by fine. The object of notification is to secure the advantages of prompt investigation of the origin and causes of diseases liable to become epidemic, the discovery of the means by which they are spread, and the application of measures of prevention.

In all cases in which the disease can be spread, either directly or indirectly, from one person to another, the isolation of the patient and the disinfection or destruction of the infectious material are of primary importance. Isolation may be accomplished by removing the sick at the earliest possible moment from the house, or, in some cases, by the removal of the well, if accomplished at the outbreak of the disease. In order to carry out the former object it is necessary to have hospitals exclusively for the treatment of these cases, and special conveyances for the transportation of the patients. In crowded houses the removal of the sick is the only possible way of checking the spread of the disease, and therefore every town should have the means of isolation.

The arrest of the spread of the disease is further to be attempted by thorough ventilation and cleanliness of the sick-room, the prompt disinfection of excreta, the disinfection of bedding, clothing, and all articles in the sick-room before their removal, and, after the recovery or death of the patient, the disinfection of the clothing, rooms, house, cesspool, etc. Disinfecting chambers should be provided by the town authorities for the immediate purification, by heat or other means, of all soiled clothing, bedding, and other infected articles that cannot be properly treated at home.

Small-pox is prevented by vaccination. Some diseases, such as typhoid fever and scarlet fever, may be propagated by the agency of contaminated water, or milk, or other food. Epidemics have originated in this way. The origin of the disease is therefore to be inquired into, in order that measures may be intelligently employed for checking its spread.

During the prevalence of an epidemic unusual measures may be required for the public safety, such as house-to-house inspection for detecting concealed cases of disease and insuring their proper management, the placarding of houses of the sick for preventing intercourse with them, the speedy interment of the dead, the purification of houses and premises by the public disinfector, the erection of temporary hospitals, and the publication of information for the use of the people in dealing with the emergency. The prompt recognition of the first cases of disease is of the greatest importance, as upon it will often depend the possibility of preventing its spread.

Maritime and Inland Quarantine Inspection.—For the object of preventing the introduction of contagious or pestilential diseases from one country to another, quarantine stations have been established at the ports of all civilized nations, where vessels infected or suspected of infection are subjected to sanitary inspection, in order to determine whether such vessels shall be admitted to free pratique or be detained for observation, disinfection, and the application of necessary prophylactic measures. For the same purpose the restriction of intercourse by land with places infected with dangerous communicable diseases is sometimes a necessity. Absolute isolation, or suspension of all communication with the infected place, is impracticable and unnecessary, since the risk of introducing disease from infected places can

be greatly diminished, if not prevented, without stopping or retarding to any considerable extent commercial intercourse, by establishing a system of sanitary inspection of passenger trains, boats, and vehicles conveying persons or goods from such places. In foreign countries the inspection service is conducted by the national government. In this country, in the absence of a national health bureau, it would be best to have such a service organized under the State boards of health, and practised on the frontier, on the lines of travel from the seaboard to the West, and in the vicinity of the infected locality. By concerted action between the State authorities, and with the co-operation of the National Government, the means necessary for restricting or suppressing epidemic disease can be most effectually carried out. Such action would be a guarantee of protection to the public health, which would prevent panic and demoralization, and disastrous obstructions of commerce and the stoppage of trade and travel.

The efforts made to protect the Mississippi Valley against yellow fever, and the West and Northwest against small-pox, by a system of sanitary inspection maintained by the National Government, and carried out along the lines of travel without embarrassing commerce or travel, have been attended with the best results, and prove the value of this service. The stream of immigration which pours into the great Northwest direct from the seaports of the country has made advisable, during the prevalence of dangerous infectious diseases at the ports of embarkation, the establishment of inspection stations at the railway centres along the lines of travel, for the examination of immigrants who may have developed the infection after leaving the seaboard, and for the inspection of baggage and the vaccination of the unprotected.

The inspectors employed for this duty should derive their authority from the National or State Governments, and, in order to facilitate their labors, they should seek the co-operation of local boards of health and of the railway and transportation officers. Provision should be made for the isolation, care, and treatment of the sick, and for the detention and isolation of suspected cases; for the ready use of disinfectants, the cleansing and disinfection of cars and boats, and for the disinfection of the clothing and baggage of the passengers. If the disease is small-pox, all unprotected persons who have been exposed to the contagion should be vaccinated; if they refuse to be vaccinated, they should be turned back, unless exempted for good or sufficient reason. The examination should include all parts of each vessel and train, and each passenger and all baggage, etc.

It is important to know the place from which the passengers have come, and the destination of any persons suspected of conveying or harboring a dangerous communicable disease. All bedding, wearing apparel, or other articles liable to contain infection, arriving from suspected places, should be unpacked and disinfected before being allowed to proceed. When practicable, special provision should be made for the disinfection of clothing in cars while on the route.

The sanitary condition of the cars should be inquired into, and the quality of the drinking-water and the ice used in it closely scrutinized. If from any cause it is unsatisfactory, the fact should be noted, and steps taken for its immediate improvement. The inspecting officers should make frequent reports to the authorities under which they act, and should communicate to local and State health-boards any facts coming within their knowledge which may be of advantage in preserving the public health. Publicity should be given to the objects and requirements of the service, in order to enlist co-operation and prevent needless attempts to evade the law.

The sanitary inspector, in whatever line of duty employed, should form the habit of taking accurate notes of the particulars of his examinations, and of the action taken in each case. These notes will form the basis of more permanent records, and of reports which he will be required to make, from time to time, to the sanitary authorities. The notes should be terse but clear, and they should embody a condensed statement of pertinent observations and recommendations. In order to systematize and render less onerous the work of record-keeping, printed forms containing the subjects of inquiry should be made use of. These forms, with the observations legibly written in ink, if bound, paged, and indexed—a plan advised in making a sanitary survey of a town—will make a valuable record for future reference.

William H. Ford.

SANITARY INSPECTORS, DUTIES OF. Sanitary inspections or examinations have, until within the last few years, been made by members of the medical profession in their capacity either of family physician, or of local health-officer, and in every case have had for their object the study of all possible conditions affecting the health of the individual, the household, or the community which the physician was called upon to investigate.

The opinion, however, is rapidly gaining ground that there are engineering problems involved in preventive medicine worthy the attention of the best talent; and with the growth of this opinion a new department in the engineering science, called "sanitary engineering," has sprung into existence. As a result the requirements of the position of inspector have greatly increased, and now involve special study and training.

The inspector, to be properly qualified, must have a thorough knowledge of medicine, so far as it relates to the exciting causes of the zymotic or preventable diseases; of engineering, so far as it relates to water-supply, sewerage, and the drainage of land; of chemistry, to enable him to determine correctly the characteristics of drinking-water; of plumbing, and of the principles of ventilation. If, in addition to these qualifications, is added a mind not hasty in forming opinions, the result of the examination will usually be a solution of the problem.

The inspector should provide himself with a note-book in which he should record all facts learned by questions and by observation, together with sketches of the location and arrangement of the buildings, their water-supply, plumbing, drainage, etc. He should never trust his memory, but enter every little item, no matter how seemingly unimportant. Besides this, the inspector can much more readily grasp the case and be able to make an intelligent report, by paying attention to small matters. When making an inspection, time should not be taken into consideration. What is required is an absolute mastery of the facts. Besides the note-book it is well to carry a hammer, cold-chisel, screw-driver, a small monkey-wrench, an ounce-bottle of oil of peppermint, about two feet of ¼-inch rubber tubing, a small funnel, and a wet and dry bulb hygrometer such as is used by the Coast Survey. These can be fitted compactly into a small box, so as to be readily portable.

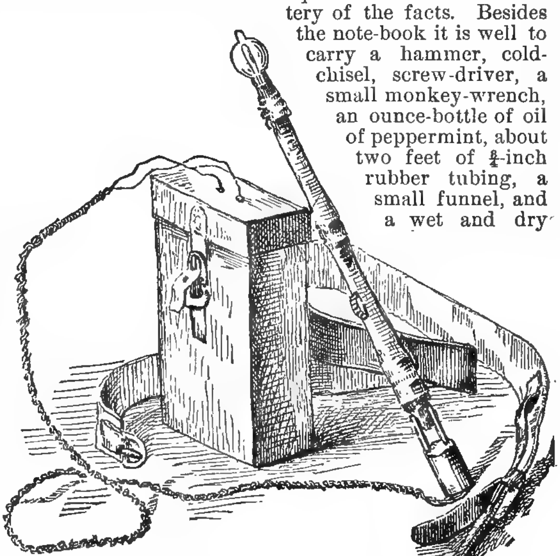

FIG. 3368.—Portable Electric Lamp and Battery, for use in sanitary inspections.

The preceding sketch (Fig. 3368) represents a one-candle power electric lamp and battery, arranged to be strapped around the waist. It is exceedingly convenient, and is free from the objections of candles or wax-tapers. It can also be lowered into a cesspool, drain, or other place difficult of access, and is not affected by draughts of air, the great enemy of naked lights. The only hinderance to the general adoption of this lamp is its cost.

There are three lines of investigation in every inspection: 1, The occupants of the house or the inhabitants of the town; 2, the surroundings; 3, the house proper.

I. The Personal.—This is, perhaps, the most troublesome part of the inspection, owing to reticence on the part of the people when questioned as to their mode of living. This may be dispensed with if there is no disease in the house or locality at the time of the inspection. Usually, however, under our existing boards of health, the only time when thorough inspections in small communities and villages are made, is during or after an outbreak of one of the preventable diseases. In such cases the first point to be learned is the date of the first appearance of the disease in the community; then each case should be marked on a map of the village or town, with the age of the person and the date of the appearance of the first symptoms. If possible, the family physicians should be consulted, and the history of the cases, together with any hereditary or constitutional complications of the patients, be obtained. In the case of the first person taken ill, if the beginning of the period of incubation of the disease corresponds in time with the residence of the patient at some other place than that at which the disease made its appearance, it is safe to assume that the specific germ was taken into the system at that place. When the cause of the disease in sporadic cases has been traced in this way to some remote place, a complete inspection of the premises is, of course, unnecessary, but it would be well to examine them for any sanitary defects that might lower the vitality and check the convalescence of the patient, or might convert the locality into a centre of contagium. When disease is found among school-children, or among persons who are confined to their places of business, the store, counting-house, or school should be thoroughly examined.

II. The Surroundings.—This line of inquiry comprises the geology of the district, the water-supply, disposal of excreta, etc. In cities where the natural water-courses have been subverted by the grading of streets and filling in of ground, the character of the soil has very little effect on the salubrity of the dwellings; but in the country it is quite the reverse, and the presence of sand or gravel, clay or rock, very often determines whether a locality shall be healthy or the reverse. Sand or gravel is the best foundation on which to build, but even this is unhealthy if it exists in the form of a bed superimposed on a depression of clay, or as a thin covering of the rock beneath.

Dampness of soil is now recognized as the prime factor in the production of pulmonary troubles, as well as a necessary attendant of malaria. The remedy is the under-drainage of the land with porous tiles, and the inspector should recommend such work to be done in every case. "Situations at the base of hills are particularly unhealthy, as the ground-water, coming from the higher lands, is checked in its flow by the sudden change in the grade and forced to the surface," making the upper layer of the soil extremely moist. The health of a community is very often affected by the presence of streams, ponds, and marshes. Streams are dammed up and overflow large tracts of land, which are at times laid bare by the subsidence of the water; while the surfaces of ponds and marshes are constantly fluctuating, alternately covering and laying bare large areas of mud. Malarial diseases are the certain result of this condition of things; but they as certainly decrease as drainage is instituted and the water-level made unvarying.

The loss of sunlight, the want of free circulation of air, and the odor of decaying vegetation given off in the autumn by the dead leaves that accumulate about a house that is densely shaded by trees, all conduce to make it damp and unhealthy. A thorough pruning of the trees nearest the house should in these cases be recommended.

The dangers to health from without the house that are most frequently met with in cities are:

1. *Badly Built and Filthy Streets.* Whatever material admits of depressions or cracks, in which surface washings can accumulate and from which they can leach out into the earth below, should be rejected as unfit for the purpose. Surface water from the yards in the rear, and from imperfect roadways and gutters in front, saturates the ground about the houses, and presents conditions favorable to the development of pulmonary diseases. The writer has learned, through a long series of observations, that ninety per cent. of the cellars in the city of New York are damp, if not actually wet, a condition largely due to this percolation from the surrounding ground.

2. *Defective privy-vaults,* fouling the air and saturating the ground.

3. *Offensive Trades.* These will be treated under the proper heads.

Water for domestic use is obtained either from the regular town-supply or from wells and springs. In the first case, it is natural to infer that sufficient care has been taken in the choice of a source and in the protection of the gathering grounds to prevent the contamination of the water. It often happens, however, that towns along the banks of streams are obliged to take water that has been fouled by the discharge of sewage or manufacturing waste from some town above them on the same stream. Although the water of streams thus polluted becomes again fit for drinking by the oxidation of its impurities, it is still a mooted question at just what distance below the point of contamination so desirable a result is reached.

Too much attention cannot be bestowed on the wells of a district, and great care should be taken in examining their location and surroundings, and the influence of the geological formation on the purity of the water.

In making the examination of the water there are three points that should receive special attention:

"1st. To what extent it is contaminated.

"2d. The causes that have led to this result, or that may produce it in the future.

"3d. The tracing of connection between the use of contaminated water and cases of disease that usually have their origin in such use, viz., typhoid fever, diphtheria, etc."

It sometimes happens that the food has more to do with an outbreak of fever than have plumbing and drainage. For instance: "Milk has so often been the carrier of contagium that everything which in any way could affect it should be carefully examined; the dairy from which it comes, the cows, the milk-cans, and the water they are washed in, should all receive attention. Then, again, the ice may be the cause of the trouble. Impure water in freezing does not make pure ice, and hence the pond or other sources from which it is taken should be examined for any possible cause of contamination."

"The only protection for a well that is deemed necessary by the majority of farmers and the like, is to raise the top by banking the earth above the level of the surrounding ground." This does not in any way affect the quality of the water, as the well draws its supply from under ground, in the manner illustrated in the article on Soil.

"Oftentimes wells are found without curb of any kind, and receiving the surface drainage from barns, pigsties, and out-buildings. Wells are sometimes dug under a house, or, having been formerly outside the kitchen door, have been brought under the roof of an 'extension,' perhaps with the pump in the kitchen. This arrangement is sure to lead to contamination of the water, as decay is going on in every conceivable form at their very mouths, and, being closely shut in, there is no chance for ventilation. When the well is near the back door, the slops that are certain to be thrown out on the ground will find their way into it."

These are some of the dangers of contamination of well-water from surface washings; but those that threat-

en the purity of the water from beneath the ground are even greater.

If a well is in a depression or below the level of barns, houses, privies, and the like, even if they be a hundred feet or more distant, its water should be looked on with distrust and a sample should be taken for analysis.

It sometimes happens, as illustrated in the article on Soil, that although the top of a well is at a greater elevation than a neighboring source of contamination, its bottom is far below, and is constantly receiving infiltrations of decomposing matter. These statements go to show that, in making a sanitary examination of a locality, no dependence should be placed on wells unless they have been proved, by absence of improper surroundings, by the geological formation of the ground in which they are dug, and lastly by a chemical analysis, to contain water fit for domestic purposes.

Privy-vaults are so common that they need no description. They are nasty, unnecessary, and extremely dangerous to health. The inspector should set his face against them and condemn them without mercy.

The proper substitute for the privy-vault, in any given instance, depends on a variety of conditions. If the town is provided with sewers, the premises should be connected with them. Country houses without running water might with advantage adopt the dry-earth system. If, however, the building is a large one, with hot and cold water supplied throughout—such as country residences, hotels, public institutions, and the like—the proper method of sewage-disposal is a matter requiring careful consideration, and the services of an engineer familiar with the construction of sewage-works should be obtained. If the town or village under examination is provided with a public water-supply, but no sewers, every argument should be brought to bear to induce the prompt introduction of a comprehensive sewerage system.

"Next to the privy-vault, the pig-sty, as it is usually met with in the country, is one of the most offensive and dangerous nuisances that will be found. These pens are sometimes quite near the house for convenience sake; the excrementitious and liquid filth is always allowed to soak into the ground. The floor is dug out every year and used as a fertilizer, leaving a pit from one to six feet deep. Some of these pits have water standing in them during hot weather, and have fetid mud in them all the time." In hot weather they become very offensive, and, when in populous districts, should be moved without delay.

III. The House.—Less attention is given to the disposal of household dirt than to any of the other questions bearing on the health of the occupants, and yet it should be recognized by the inspector as an important factor. Charles Slagg says: "One must consider that there are two kinds of dirt—the one mineral and inoffensive, the other refuse organic matter. We do not feel defiled by contact with the one, but contact with the other is abhorrent, and there ought to be in every household a sufficient quantity of water to wash it off frequently. Those who suffer the dirt which is caused by the perspiration of the body to linger underneath the clothes, out of sight, are essentially dirty. We cannot all be rich, but we can all be clean." The dust that accumulates on the walls, floors, and furniture of a house is composed of organic and inorganic matter, and would, if sprinkled on the wounds of patients in the surgical wards of hospitals, produce conditions extremely dangerous to life. The cellar should be as clean as the parlor; and yet fully ninety per cent. are so dirty and littered with rubbish that one cannot go into them without soiling his clothes. The front door-step may be taken as a criterion of the character of the inmates of the house. As it is clean or dirty, so will be its owners. "The average American house has its 'company room,' in which the chance visitor is ushered. Here everything is in order, from the gilt frame about the French picture to the velvet carpet on the floor. Go to the kitchen, and you will find the week's wash on the floor, the garbage-pail standing on the hearthstone, the remains of several meals on the table, and cockroaches crawling over everything." Go to the bedrooms and examine those receptacles of rubbish, the closets under the basins; notice the rolls of hair, the burnt matches, and dirty brushes lying on the bureau; open the closet-doors and speculate on the time that has elapsed since those clothes have been aired. All these things are sure indications of the habits of life of the occupants, and the experienced inspector notes them as carefully as he would the syphoning of a trap.

The questions to be investigated inside the house are:

A. The character of the air.
B. The mode of heating.
C. Means of ventilation.
D. Plumbing and drainage.

A. *The Character of the Air.*—The material of the outside walls (whether wood or stone) should be noted; and the rain-leaders and roofs should also be examined, for, if leaky, they are fruitful sources of moisture. The cellar also plays a very important part in the salubrity of a house. Being below the level of the ground it acts like a cesspool, receiving and holding surface-water that finds its way into it from the surrounding ground; and hence it is that cellars are usually damp, except in certain cases where great care has been taken, by concreting or asphalting the floors and walls, and by a system of underdrains, to keep the water out. Every house for at least eight months of the year resembles a chimney. The air inside, being warmer than that outside, is constantly rising and producing a vacuum that must be filled from somewhere. Windows and doors, and even brick or wooden walls, leak air; but this vacuum is partly filled by air drawn from the ground around the house. Ground-air has always more or less decaying matter in it, and has been known to carry contagium. Care should therefore be taken to prevent the cellar from drawing its supply of air from the surrounding ground, by the opening of windows and doors and the sustaining of good ventilation.

The cellars in country houses, as usually found, are very objectionable. "They very seldom extend under the entire house, and are, as a rule, reached by a steep flight of steps from the outside. In many instances the door is the only opening for light and air, the result of which arrangement is that the walls become damp, the beams rot, and the atmosphere is heavy with moisture. In these cellars will be found vegetables, apples, and sundry other household goods stored for winter use." The decay of these things makes the air foul, and more or less affects the atmosphere of the house, as explained above.

Another source of nuisance in the country is the air-space that is often left under a house. Refuse of all kinds—dead animals, etc.—collect here, and being difficult to reach, will never be removed. "When the cold weather comes on, these houses are banked with earth, saw-dust, leaves, manure—whichever is most available. The surface of the surrounding ground is frozen, and thus hermetically sealed. It follows that any sweating of the earth, or movements of air or gases in the soil, must work up under the unfrozen part beneath the house. As the temperature is always above freezing-point, some decomposition goes on all the time; these gases mingle with the others, and all winter they rush through the cracks in the floor into the living-rooms above. Fortunately, most of this class of houses have been rocked by the wind, shrunk or warped by sun and rain, until the entrance of pure air from without balances in most cases the vitiated air within." The effect of cellar-air on the atmosphere of a building should be further determined by the use of a wet and dry hygrometer. The instrument should be set in turn out of doors and on each floor, including the cellar. The readings should be taken not less than fifteen minutes after setting, as this is the minimum time in which the columns of mercury will come to rest.

B. *The Mode of Heating the Building.*—With the mechanical details of steam and hot-water heating the inspector will have nothing to do further than to note the ability of the apparatus to keep the building at a uniform temperature of 70° F. The air-supply to these apparatus,

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if heating by indirect radiation, as well as that to the ordinary hot-air furnace, is of the greatest importance, and the position of the inlet and the condition of the flues should be carefully examined. "Cracks or openings in the ducts, or the position of the air-inlet near the drain-opening or other source of contamination, will allow foul air to pass into the heating chamber and be distributed through the house." The air-tight stoves so often met with in country houses are an abomination. The air in the room is heated and reheated, and breathed over and over again until the vitality of the system is so lowered that a person who has been subjected to the bad air for some time experiences a severe chill when passing into purer, fresher air.

Dr. D. F. Lincoln, in the New York State Health Board Report for 1882, makes some extremely good suggestions for the turning of these stoves into ventilating apparatus, and the inspector would do well to familiarize himself with them. Dampers in the smoke-flues of both hot-air furnaces and stoves are a source of great annoyance. When the fire is too hot, these dampers are closed and the carbonic acid gas arising from the combustion of the coal forces its way into the rooms, sometimes to suffocation. There ought to be no dampers of this kind, as it is quite possible to regulate the fire by the doors, if the furnace is properly constructed. When the owner will not dispense with them, there should be a small leak-hole cut in the disk to allow the noxious gases to pass up the chimney.

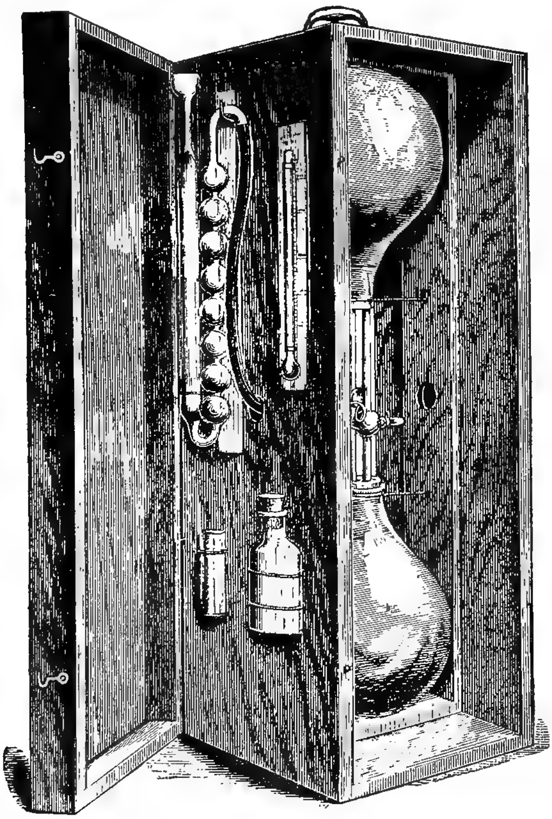

FIG. 3369.

C. *Means of Ventilation.*—Doors and windows are the sole reliance in this direction in most buildings. The air of houses would be very much improved if a good-sized opening, properly protected by louvers, was made in the roof. This would allow the constantly ascending warm and vitiated air of the building to pass out at the roof and be replaced by pure, fresh air. The skylights over stairways and light shafts in city houses will usually be found closed tight. The inspector should recommend them to be raised a couple of inches for the above-mentioned reasons. No part of the house needs ventilating more than the water-closets, and yet in many cases they will be found in the middle of the house, far from any window. The foul odor must of necessity pass out into the rooms and taint the air. Persons who are accustomed to living in city houses do not notice this odor, but it is very perceptible to those whose lungs are usually filled with the pure air of the country. The inspector should look well to this matter of ventilation. When water-closets are very much shut in, he should recommend the carrying of a ventilating-tube from the closet to some point outside the house; and the heating of the air contained in it by a gas jet, or a similar method, which will create an outward current of air at all times. This will prevent the foul air from passing out into the house by creating a strong counter-current.

In the examination of school-houses, dormitories, and the like, it will be necessary to test the character of the air with respect to the presence of carbonic acid, in order to ascertain the efficiency of ventilation. A convenient method, and one given by Dr. John T. Billings, is to take "six well-stoppered bottles containing, respectively, 450, 350, 300, 250, 200, 100 c.c., a glass tube or pipette, graduated to contain exactly 15 c.c. to a given mark, and a bottle of perfectly clear and transparent lime-water." The bottles are filled with the atmosphere to be examined "by means of one of the smaller hand-ball syringes, taking care that none of your own breath is pumped in; add to the smallest bottle, by means of the pipette, 15 ctm. of the lime-water, put in the cork, and shake the bottle. If turbidity appears the amount of the carbonic acid will be at least 16 parts in 10,000." Turbidity in the 200 c.c. bottle would indicate 12 parts; in the 250 c.c. bottle, 10 parts; in the 300 c.c. bottle, 8 parts; in the 350 c.c. bottle, 7 parts; and in the 450 c.c. bottle less than 6 parts.

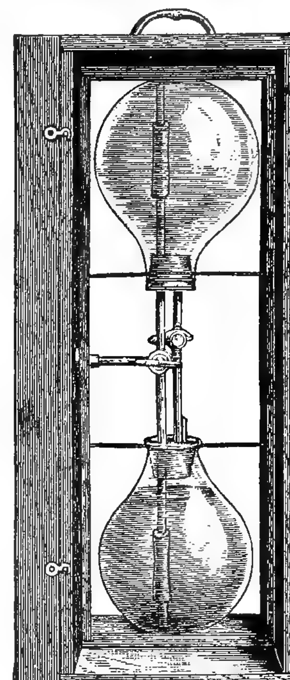

FIG. 3370.

Another simple method, and one devised by the writer, depends on the characteristic action of phenolphthalein, one of the aniline colors, which in an alkaline solution is a brilliant crimson, but in an acid solution is a dull yellow. The method is thus described in the *Sanitary Engineer:*

Fig. 3369 shows the apparatus enclosed in a box. It consists of two graduated glass flasks, Fig. 3370, set in a revolving frame, and connected by a glass tube furnished with a stop-cock. The tubes connect with the three-way cock, which allows air to enter one or the other of the flasks at pleasure. The U-shaped glass, Fig. 3371, has eight bulbs blown on one of the legs to insure the perfect absorption of the carbonic acid by the baryta-water.

To use the apparatus, fill the upper flask to the zero mark with water (this may readily be done by attaching the end of the flexible tube to a faucet); pour into the absorption-tube, through the funnel, from 12 to 15 ctm. of baryta-water containing 3.425 milligrammes of baryta (BaO), which will absorb one-half a cubic centimetre of

carbonic acid gas; turn a three-way cock so as to connect the upper flask with the absorption-tube; turn the stop-cock so that the water will pass from the upper into the lower flask; aspirate slowly till the color disappears; shut the stop-cock, and read on the graduated flask the number of cubic centimetres of water run out, and hence the

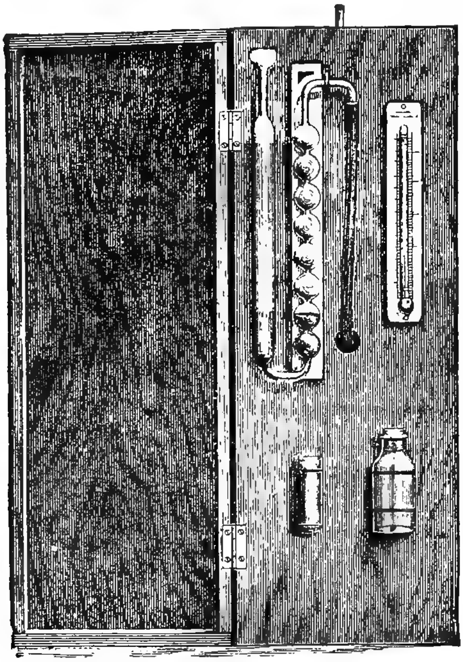

FIG. 3371.

amount of air passed through the baryta-water. If 1,000 c.c. of water have been used, the proportion of carbonic acid is 5 parts in 10,000. As air changes its volume under varying pressures and temperatures, corrections must be made for these in order to obtain absolutely correct results. Should it be necessary to pass more air through the baryta solution than is contained in one flask, turn the stop-cock, close the air-hole in the flask containing the water, revolve the aspirator, open the air-hole in the empty flask, reverse the three-way cock, and proceed as before.

D. *Plumbing and Drainage.*—The defects in this work that may be encountered are almost without number. A list of such defects that have been encountered by a firm of English engineers, has been slightly altered to meet American practice, and is given here as being a concise statement of the experience of the writer: "1. Common brick sewers with flat bottoms, under or near houses. 2. Earthen pipe-drains, either broken or with leaky joints, laid under the cellar floor, saturating the earth with sewage. 3. Pipe-drains, either earthen or iron, laid under houses without sufficient fall, or with the fall the wrong way. 4. Drains, both earthen and iron, without running traps, admitting air from sewer and cesspool to the pipes in the house. 5. Drains without a free current of air moving constantly through them. 6. Rat-burrows from built drains or sewers undermining flags and floors, and admitting foul air to the house. 7. Rat-burrows worked along perfect pipe-drains from street sewers and into houses. 8. Defective connections between soil and waste pipes, and sewers admitting foul air to houses. 9. Soil or waste-pipes without any or sufficient ventilation. 10. Defective water-closet apparatus. 11. Water-closet cisterns with overflows joined to waste-pipe or drain. 12. Safes under closets or basins, connected to soil-pipe or drain. 13. Two or more fixtures with unventilated traps on the same line of pipe, siphoning each other when used. 14. Sink overflow-pipes joined to soil-pipes, untrapped or with trap liable to siphon. 15. Overflows from basins or baths connected with waste-pipe on sewer side of trap. 16. Water-supplies to sinks taken from water-closets or other contaminated cisterns, and used by careless servants for drinking purposes. 17. House cisterns and tanks with overflows direct into soil-pipes or drains. 18. Traps of every description without ample ventilation to prevent them from siphoning. 19. Scullery sinks connected directly with drains, admitting foul air to houses, not only through traps, but through joints of brickwork all around, as shown by the smoke test. 20. Bell-trap with loose covers on scullery sink connected with drains. 21. Gullies or traps in sculleries, laundries, larders, refrigerators, etc., leading to drains usually dry and untrapped. 22. Rain-leaders used as ventilators to drains, delivering foul air to bedroom windows, or under eaves or roofs. 23. Ashpits near larders and pantries; ashpits liable to soak moisture through house-walls. 24. Defects of drainage and rat-burrows from neighbors' houses. 25. Water-cisterns in areas near ashpits or sculleries, and with overflows directly to drain. 26. Wash-basins in dressing-rooms connected directly in any way to drains or soil-pipes. 27. Cisterns of all kinds in houses with overflow connected to drains. 28. Cesspool near houses, and cesspools or defective drains near walls. 29. Neighbors' drains crossing under houses, or joining drains."

The plumbing system of a building may be likened to a tree, the house-drain being the trunk, and the waste-pipes with the fixtures at their extremities representing the branches. The inspector will find it best to begin his examination in the cellar and work gradually to the roof, making sketches of each floor, and the arrangement and connections of all the pipes in the house. Unfortunately, it is too often the case that the pipes are hidden in walls and partitions, and cannot be got at without great inconvenience to the occupants; and yet it is necessary, for a thorough and intelligent examination, that the entire length of piping should be exposed to view. To overcome this difficulty, and also to detect the pin-holes or air-holes which often occur in pipes, and which it is impossible to see with the naked eye, two tests, the peppermint and the smoke, may be employed.

To make the peppermint test, two persons are required, one to handle the oil and the other to search for traces of it through the house. A pailful of boiling water is poured in the top of the soil-pipe, if it extends above the roof; or if not, into the highest fixture in the building. About one ounce of oil of peppermint (or any other pungent volatile substance) is next mixed thoroughly with about a gallon of boiling water and sent down the pipe, followed immediately by another pailful of boiling water. By heating the pipe at first, and then breaking up the oil into minute globules, the oil is, to a certain extent, volatilized and carried into every part of the system. When the end of the pipe on the roof is protected by a return bend, the rubber tube and funnel previously mentioned can be used to advantage for siphoning the water and oil into the pipe. When it is necessary to pour the oil down from the highest fixture, the person using it should shut himself in the closet, and remain there until the inspector has made his search for traces of the odor. Too much care cannot be taken in making this test, and at least ten minutes should be allowed between the time of pouring in the oil and beginning the search, in order to give time for the penetration of the odor to every part of the system of piping.

Quite a novel apparatus has been recently invented by John T. Phelan, of Cambridge, Mass., for making the peppermint test. It is an admirable contrivance for introducing the oil into the plumbing of a building whose pipes are not extended above the roof. "The device represented in Fig. 3372 consists of two pipes, *A* and *B*, connected together by a joint, *C*, in which joint are two openings, *a* and *b*, which extend downward and are separated by a partition, *c*. The joint *C*, is provided with an extension, *d*, on which is a flange, *f*. At the extremity of the pipe *A* is a cock, *D*, and at the extremity of the pipe *B* is a cock, *E*, and attached at right angles to the pipe *B* is a pipe, *F*, which is provided with a cock,

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G. To the end of the pipe *F* is attached in any suitable manner an elastic bag of rubber, *H*. Under the joint *C*, and at right angles to the same, is a U-shaped bar, *I*, which is attached by its extremities to the pipes on each side of the joint *C*, and in the lower part of this bar is an adjustable support, *K*, for a flask, *L*, which contains the oil of peppermint or other equivalent substance the vapor of which is to be forced into the soil-pipe. The support *K* is adjusted by a set-screw, *g*. The extension *d* of the joint *B* extends into the flask, and between the mouth of the flask and the flange *f* is placed a rubber washer, *h*, by means of which a tight joint is effected when the mouth of the flask is forced against the flange *f* by the set-screw *g*. In the extension *d* of the joint are two perforations, each of which is in connection, respectively,

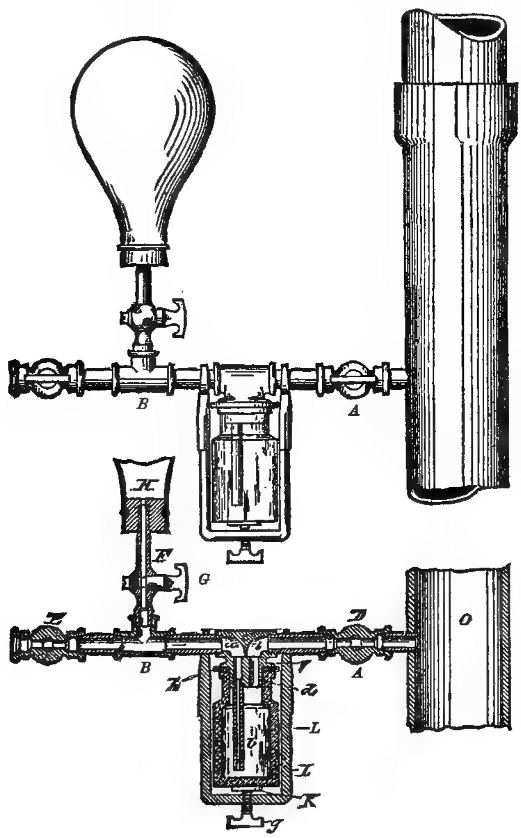

FIG. 3372.

with one of the openings in the joint. A tube, *l*, extending into the liquid in the flask, may be connected with the perforation which is connected with the pipe *B*.

"The mode of operation of the apparatus is as follows: The soil-pipe is first closed at the top and bottom and at all other openings, and the pipe *A* is then attached to a suitable opening made in the soil-pipe, or is otherwise connected with the same. The cock *D* is then closed, and the cocks *E* and *G* are opened. Air is then blown into the elastic bag *H*, through the pipes *B* and *F*, until it is expanded to any desired extent. The cock *E* is then closed and the cock *D* opened, when, by the contraction of the elastic bag *H*, a current of air is forced from the same, and, passing through the opening *a*, pipe *l*, opening *b*, and pipe *A*, carries the vapor of the volatile substance contained in the flask *L* into the soil-pipe *C*."

The accompanying cut (Fig. 3373) shows the apparatus used for making the smoke-test. It consists essentially of a fan, *a*, and a furnace, *b*, in which any substance that will make a good smoke (straw-paper, tobacco-stems, etc.) is placed. All openings in the pipes, with the exception of those on the roof, are closed, an opening is made at as low a point as possible on the house-drain, and the tube *c* is inserted in it and carefully luted. The blast is now turned on, and the furnace kept well filled with combustibles till the smoke begins to pour out of the pipes on the roof. These openings are then carefully closed, and the blast is kept up until the inspector has made his tour. This is a very good test, as the smoke is easily seen and its origin quickly traced. The machine, however, is rather cumbersome for general use, and it is to be hoped that a modification will be devised before long.

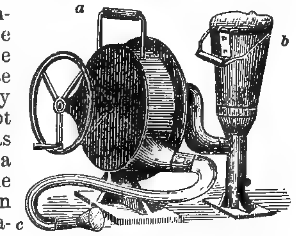

FIG. 3373.

Another form of smoke-test consists in the use of a "smoke rocket" (Fig. 3374), which resembles a Roman candle; being the same length and perhaps three times as thick. The rocket is placed at the foot of the drain, or just inside the intercepting trap, and when lighted gives off a large volume of smoke, which gradually diffuses itself through the pipes and escapes at any open joint or other defect. Although it burns for some fifteen minutes, the rocket is not as satisfactory as the blower, as the smoke can be forced to every part of the system of pipes by the latter, while the former is dependent for diffusion on the currents of air in the pipes. These, as we have seen, may often be down in one pipe and up in another, when the system is somewhat complex.

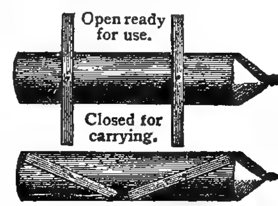

FIG. 3374.—Smoke Rocket.

A recent form of drain-tester is the "drain grenade," made in London (Fig. 3375). "It consists of a cylindrical

FIG. 3375.—Actual Size of Drain Grenade.

vessel, made either of gelatine or thin glass, about two and a half inches long by three-eighths of an inch in diameter. It is charged with either peppermint, assafœtida, or a special pungent compound. The 'grenade' is thrown down the drain to be tested, due care being taken in the case of the glass one that it shall have sufficient fall to break, whereby the content is, of course, released. In the case of the gelatine 'grenade' the filling is, of course, released as soon as the gelatine is dissolved. A little hot water is thrown down the drain after the 'grenade,' in order to flush it through."

When the house-drain is laid under the cellar floor, the smoke and peppermint tests will not detect defects. In such cases the following test should be made: "Select some inlet where you would have a pressure from a head of from two to six feet; plug up all the openings whose outlets are below that level, and also plug up the connection into the manhole or other outlet from the house-drain to the main sewer. The whole system of underground pipes can then be filled with water up to a certain level, care being taken that the outlet at the manhole is perfectly stopped with pugged clay or other means. If the water remains up to the original level, and does not sink or disappear, it is proof there is no leakage from the pipes. The pipes should be filled under the eye of the inspector, so that no tricks may be played; for instance, in the case of new houses where the drains have just been covered in, the inspector should know approximately what quantity of water is required, and should not be content to find the pipes already filled for him, or be

might discover, perhaps, that a false plug had been put in the first length of pipe and the water prevented from passing beyond the first joint. By seeing the removal of the plug from the manhole, such a trick as this might be detected, as the quantity of water used would then show itself if the gradient be known; but the better way is to calculate the cubic contents of the given length of drain-pipes, and measure the number of gallons put in.

When the pipes in the upper floors of a building are so laid that they cannot be reached, and it is desirable to know their exact whereabouts and connections, the work is one of great difficulty. The following suggestions may, however, aid the inspector: To the run of a pipe, allow water to run from the fixtures that are supposed to be located on it, and then go into the closets on the floor below and listen. The trickling sound of water will fix the location. Where several pipes are close together, and only one can be seen, the running of hot water from the various fixtures above, in turn, will usually serve to separate them. To test whether safe-wastes are connected to the waste-pipes from their several fixtures, or are carried by a separate pipe to the cellar, as they should be, pour water through one of the strainers and look for it on the cellar-floor. When it is uncertain whether bath and basin wastes connect with the trap of the adjacent water-closet, or discharge directly into the soil-pipe, cut off the water from the closet; or in the case of a pan-closet, take the bolt out of the lever and drop the pan. The surface of the water in the trap is thus exposed, and by running water in the various fixtures the mode of connection can readily be seen.

To test the efficiency of trap-seals, two methods are employed: First, by the production of a partial vacuum on the sewer side, which destroys the atmospheric equilibrium and forces the water out of the trap, except in cases where the weight of water in the trap is greater than the pressure of the atmosphere. To make this test, all the fixtures above and on the same line of piping are filled with water, and discharged as nearly as possible at the same time. The characteristic gurgle will announce the siphoning. Second, the fixture is filled with water, and all rotary currents are checked; the plug is then gently raised and the contents allowed to rush out. Traps siphoned in this way are siphoned by the momentum of the water. The gurgle is not always a sure indication of the breaking of the water-seal, but the mere fact of a trap being sensitive should be sufficient to condemn it.

The following schedules are given here as suggestions for use in sanitary inspections, and by means of which the sanitary value of a house may be estimated. The first was prepared by Dr. William K. Newton, health-officer of Paterson, N. J., and is designed for country and suburban work. It has been in use for two years, and has proved of great value. The second schedule was prepared by the writer for the use of the New York Tenement House Commission, and is applicable to large cities. The use of similar schedules will be found of great value in tabulating and arranging sanitary statistics, and the writer, from personal experience, strongly recommends their adoption by boards of health.

Schedule for the Sanitary Survey of a House.

(The inspector will cross out all but the correct words, and will fill in spaces.)

Date........................

....................Street, Number............

Street runs N., E., S., W. Width .... feet. Grade........
Pavement.—Cobble, block, Macadam, Telford, none.......
Gutters.—Paved, curbed, smooth......
Sewer.—Material, brick, pipe......; size......; shape......; depth below surface... feet; fall....inches to....foot; runs into........ Street sewer; condition..............................
Condition of street and gutters ....
....
Shade-trees.—How far from house........; prevents sun exposure? ....

Site of House.

......feet above the sea-level.
Soil.—Gravel, sand, clay, loam, rock, made ground, filled in with ......; site of swamp, old water-course, pond, damp, dry. Was site drained before building?......; how?... ..; is surrounding land higher than site, or lower? .....

Diagram of Lot.

w,—well.
c.—cistern.
p.—privy.
c.p.—cesspool.
c.b.—catch-basin.
......drain.

front.

Width of alley, if any......
Yard.—Paved, flagged, cemented, drained, clean, slops, garbage.
Privy-vault.—Stone, brick, board, none, water-tight, connected with sewer, supplied with water, clean; how near living-rooms......
Water-closet.—Style, clean......
Cesspool.—Stone, brick, tight, leaching, connected with sewer......
Water-supply.—City, well......; depth of......; cistern......
Distance of well from source of pollution......
Analysis of water.

House.

Owner......
Agent......
Tenement.—Private, boarding-house......
House faces N., E., S., W.; sun exposure, good, bad; 1-, 2-, 3-, 4-story; number of rooms... ..
Construction.—Brick, stone, wood; sheathed before clapboarding ......; fire-stop......
Roof.—Tin, shingle, slate, tar, gable, flat, French, leaky......; scuttle......; fire-escapes .....
Size of house......; size of lot......; ratio of unoccupied space......
Back-building, distance from house .....
Cellar.—Foundation, stone, brick; how laid......; asphalted or cemented......; damp course......; depth below sidewalk......
Floor.—Cemented, asphalted, stone, board......; dry, damp......
Water-closet.—Condition......
Windows.... ......Is room used for sleeping-room, living-room, shop?
Ventilation of house......
Illumination.—Window-space......
Rooms not connected with external air......
Heating.—Fireplace, stove, furnace, steam; has furnace an air-box?
Plumbing.—Is house connected with sewer or cesspool?......; angle of connection with sewer......
House-drain.—Lead, iron, earthenware; size.....; fall.....; calked joints, cement joints; how fixed in cellar; under ground or exposed ......
Main trap......; inlet for fresh air......
Soil-pipe.—Iron, lead......; size......; joints......; angle of connection with house-drains... ..; extend above roof......
Does ventilating-pipe run into soil-pipe?......
Traps under fixtures......; traps vented......
Water-closets.—Number......; pan, hopper, plunger, siphon......; sufficient wash......
Are there any adjoining nuisances?......
Are fowls, goats, or cattle kept on premises?......

Vital Statistics.

Population of house......
Number under five years of age......
Number of families......
Number to each family......
Number of rooms to each family......
Diseases reported.—Scarlet fever, diphtheria, typhoid fever, dysentery, diarrhœal diseases......
Deaths......

Schedule for Sanitary Survey of City House.

File No........

Date........................18....

Inspector......; House......; No. of stories......; Material......; Built about how long......; Single or double......; No. of families on floor......; Owner......; Address......; Is name posted?......; Duties of housekeeper......; Soil (sand, clay, rock, or made ground)......; Street, how paved......; Condition......; Size of lot... ..; Per cent. of lot covered......; House fronts......; In good or bad repair... ..; Width of areas, front......; rear......; Alley, width......; Distance between front and rear houses......; Adjoining nuisances......; Any stable in building......; Any animals or fowls kept in house......
Cellar.—Depth below sidewalk......; Height of ceiling......; How used......; Condition......; How floored......; Are walls damp?......; No. and size of windows......; Location of......; Are they kept closed? ......; How occupied or used......
House.—Stairs, width......; Condition......; Width of well-hole ......; Fire-escapes......; How located......; Are windows obstructed? ......
Halls.—Are they kept clean?......; By whom?......; Have walls settled? ....; Condition of plaster and ceiling.....; How is roof reached?......; Is roof-door locked?......; Are hallways obstructed? ......; Are halls lighted at night?... ..; How lighted by day?......; How ventilated?......
Roof.—Material......; Condition.....; How used......; Flat or sloping......; Are chimneys in good repair?......; Skylights tight or open......; Form of opening......
Garbage.—How stored......; When removed......
Yard.—How paved. ...; Size....; Is it cleanly?......; Is light obscured by clothes hung to dry?......; Privy-vault, material......; No. of seats......; How connected with sewer......; Condition......; How ventilated......; How full.....; School sink, size and condition ... ..; Distance from nearest window .....; Any complaint of odors? .... .; Water-closets, kind .....; Location......; Condition......; How flushed......; Sinks......; Trapped......; Are all traps ventilated? ......; How?......; Are waste-pipes properly jointed?......; Are sinks improperly used?......

Water-supply.—In yard, rooms, or halls......; How high does water rise by day?......; Is water wasting from fixtures?......; Pumps......, Condition......; Hydrant, condition......; How wasted?......; Tanks on roof, size......; Overflow discharges......

Heating and Lighting.—Stove......; Damper in pipe?......; Does chimney smoke?......; Is coal-gas noticed?......; Light shafts, how located?......; Size......; End where?......; Is bottom open?......; Are they used improperly?......; Size of windows opening into......; Are there side windows therefrom into courts or outer air?......; Are transom windows into hall kept open?......; Bedrooms, how lighted and ventilated?......; Are there any transom windows over doors between rooms?........

	Size.	Material.	Location.	Condition.	Running trap.	Air inlet.	How connected.	Opening where.	Soil pipe used as leader.	Soil pipe extended above roof.	Waste pipe ventilated.
House Drain............											
Soil Pipe...............											
Waste Pipe..............											
Rain Leader............											

REMARKS.

	How used.	Condition.	No. Rooms.	Adults.	Children.	Height ceiling.	Dimensions, largest room.	Cubic contents of apartments.	Nationality of adults.	Occupation.	Children at school.	Children at work.	Sickness.	No. of deaths within the year.	Cause of death.	Rents.
FLOOR.																
A.................																
B.................																
C.................																
D.................																
Total,																
FLOOR.																
A.................																
B.................																
C.................																
D.................																
Total,																
FLOOR.																
A.................																
B.................																
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D.................																
Total,																
FLOOR.																
A.................																
B.................																
C.................																
D.................																
Total,																

Summary.—Total occupants......; Adults......; Children......; No. of beggars recorded?......; No. of saloons on block front......; Any signs of drunkenness?......; Class of tenants......; Any sleeping in halls or yards?......

Frederick N. Owen.

SAN PELLEGRINO is a thermal station near Bergamo, in Lombardy, Italy, lying at an elevation of about fourteen hundred feet above the sea. The water of the springs issues at a temperature of 81° F., and contains 1.6 Gm. of saline constituents in a litre. The solids are chiefly chlorides and sulphates, with 0.022 Gm. of sodium iodide per litre. The climate is mild, and the air is delightfully pure and invigorating. The indications for the employment of these waters are said to be chronic inflammatory troubles of the liver, spleen, intestinal tract, bladder, and female sexual organs, gout, syphilis, and the so-called scrofulous diseases of the joints, glands, and skin. San Pellegrino is a favorite summer resort for families in which there are delicate "scrofulous" children. The waters are employed medicinally both internally and in the form of baths.

T. L. S.

SANTA BARBARA. The town of Santa Barbara, Cal., lies in a valley among the foothills of the Santa Ynez Mountains, close to the shore of the Pacific Ocean. The main street of the town runs down to the beach, but its thickly settled portion lies about a mile back from the beach and at an elevation of from twenty to one hundred feet above sea-level. The latitude of Santa Barbara is 34° 28′ N.; two degrees farther south than Algiers; less than two degrees farther north than Madeira. The mildness of its winter climate is, however, due only in part to the comparatively low latitude, being chiefly dependent upon its situation on the western rather than the eastern coast of the North American Continent, and also in great measure upon the trend of the coast-line at this point, and to the protection against northerly winds afforded by the Santa Ynez range of mountains. From Point Concepcion to Carpenteria, a distance of about sixty miles, the California coast-line runs nearly due east and west, a chain of the Coast Range Mountains, bearing the name of the Santa Ynez Range, running parallel to the coast-line, its chief peaks lying some twenty miles back from the shore and rising to an elevation of three or four thousand feet above sea-level. In fact, we have along this part of the California coast a counterpart of the Genoese Riviera; less extensive by half than the latter and backed by mountains less elevated and farther removed from the coast-line, so that the term "cornice" (La Cornice), which is applied to the Genoese Riviera, would hardly be applicable to this far wider Riviera, or coast country, of California. Protection alone gives to the Cornice a mildness of winter climate to which by its latitude it is not entitled; less perfect shelter against northerly winds along the California Riviera is but an adjunct of low latitude and proximity to the warm water of the Pacific in causing the *superior* mildness of its winter climate.

Santa Barbara is the largest town in this part of California (population, about five thousand), and as it is beautifully located, and is one of the most attractive places—perhaps the most attractive place—in all Southern California, it is doubtless destined to increase greatly in size so soon as the chief obstacle to such growth, lack of direct railroad communication, is removed. The water-supply is "abundant and excellent" (Dr. W. M. Chamberlain in New York *Medical Record*, October 30, 1886); of the drainage I find no specific mention. There are excellent hotels, and we are told by a recent writer on Southern California (Wolfred Nelson, C.M., M.D., in the *Planet* of January 15, 1884) that living expenses are moderate. Many of those who resort to Santa Barbara very wisely follow the plan of living in their own cottages rather than at either of the large hotels; boarding-houses also exist for such as prefer them. Dr. Nelson speaks of still a fourth method of living which is adopted by some persons, viz., the renting of furnished rooms near a hotel and taking one's meals at the hotel. Riding is the most popular form of amusement at Santa Barbara; fishing, hunting, boating, and bathing are also in vogue; and the beach is not only a good one for this latter form of recreation, but is so hard as to be likewise available for riding and driving. As to bathing, it may be practised at all seasons of the year, as the sea-water is never very cold; but the season proper begins in May. The mean temperature of the sea-water for each month of the year is given by Dr. Nelson, on the authority of Mr. John P. Stearns, as follows:

January ...60°	April ......61°	July........64°	October.....63°
February ...61°	May........61°	August .....65°	November...61°
March......61°	June........62°	September..66°	December...60°

This would give a mean for the five months, November to March, of 60.6°, a temperature 3.5° higher than the mean surface-temperature of the Mediterranean during the same season at Cannes, as quoted by Dr. Sparks from a paper of Dr. Tripe's (see Sparks's "Riviera," p. 7).

CLIMATE.—The chief objections to the Santa Barbara climate appear to be that it is less dry than that of inland and higher-lying stations in Southern California, is liable to fogs, and is rather exceptionally windy—exceptionally, that is, for a South California station. Dr. H. S. Orme, president of the California State Board of Health, speaks of the land- and sea-breezes as "nearly always to be found" along the coast of this part of the State, and as being "very noticeable at Santa Barbara, Santa Monica, and San Pedro; perhaps less so at San Diego" ("The Climatology and Diseases of Southern California").

I have no data showing the force of the winds at Santa Barbara, but at San Diego we see, from column S of the chart published under that heading, that the mean velocity of the wind is remarkably small. From column K of the accompanying chart it would appear that Santa Barbara possesses a drier atmosphere than San Diego; yet hardly so dry as to warrant the assumption that it is what can be rightly termed a dry place, and Dr. W. M. Chamberlain (*loc. cit.*) evidently regards it as very inferior in this respect to the inland California resorts. "Like San Diego," he tells us, "it is very damp, as the moss-covered roofs and lichen-encrusted fences indicate. More than San Diego it is windy, for it lies in a trough between the hills opening to the southeast and northwest; up this valley the fogs roll in the early hours of the day, and whatever winds there may be are compressed and accelerated to an unusual force." In other respects, the Santa Barbara climate appears to be all but ideally perfect—warm, sunny, and equable; and, lest what has just been said concerning its liability to fogs and *comparative* liability to winds should produce an unduly dark impression of its claims as a health-resort, I introduce the following passage, quoted from Appleton's "Handbook of Winter Resorts" (1886–87). The "only serious drawback" to the climate of Santa Barbara, according to the writer in this guide-book, is the fog which "sometimes comes in from the sea." Such a fog occurs, on the average, perhaps twice a week between May and September, he tells us, but he adds that these fogs "disperse at nine in the morning, and the succeeding weather is delightful."* "Mr. Nordhoff," he says, "expresses the opinion that there were but 'five days, either in Santa Barbara or San Diego, in December, January, and February of this year (1871), in which the tenderest invalid could not pass the greater part of the day out of doors with pleasure and profit. In Santa Barbara there were not a dozen days during the whole winter in which a baby I know did not play on the sea-beach.'"

The following "record of the weather at Santa Barbara for one year, kept by ———, an invalid with advanced pulmonary disease," is quoted from Dr. Nelson's paper already cited.† According to the observations of the gentleman in question, made during a leap year (366 days), there were "310 pleasant days, so that an invalid could be out of doors five or six hours with safety and comfort; 29 cloudy days, upon over twenty of which an invalid could be out of doors; 12 showery days, upon seven of which an invalid could be out an hour at a time several times on each day; 10 windy days, confining the invalid to the house all day; and 5 rainy days, also confining the invalid to the house during the whole of that time."

Santa Barbara not being a station of the United States Signal Service, I am obliged to rely on the reported observations of various volunteer observers for the data quoted in this article and presented in the accompanying chart. All the figures of the chart are either copied from or calculated from those given in Dr. Nelson's article. The headings of the various columns of the chart sufficiently indicate the value of the data in each as an index of the habitual weather, or climate, of Santa Barbara. One of Dr. Nelson's tables shows the temperature observed at 7 A.M., 2 P.M., and 9 P.M. of every day during the year 1879, and the average daily temperature at the hours specified during each month of that year, the observations having been taken by Dr. L. N. Dimmick. Another of Dr. Nelson's tables gives the highest, lowest,

* How frequently these morning fogs occur during the months between September and May we are not told.

† Dr. Nelson gives the name of the gentleman who kept this record, which name I omit, not having asked permission to publish it in the HANDBOOK.

Santa Barbara.

	A			AA†	B	BB†	BBB		T	V	E		F	
	Mean temperature during the year 1879 at the hours of			Mean temperature of 1879 deduced from Column A.*	Mean temperature of 1879 as given by Dr. N.**	Mean temperature for a series of years, 1871-79.**	Mean temperatures during series of years, 1871-79.**		Average of monthly maxima at 2 P.M., 1871-79.	Average of monthly minima at 2 P.M., 1871-79.	Absolute maximum temperature at 2 P.M., 1871-79.		Absolute minimum temperature at 7 A.M. or 9 P.M., 1871-79.	
	7 A.M. Degrees.	2 P.M. Degrees.	9 P.M. Degrees.	Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.
January	46	60	46	49.5	51.00	53.08	56.00	50.37	73.1	39.5	83	67	42	38
February	51	63	58	57.5	57.00	54.69	59.00	52.01	72.4	41.5	79	67	46	39
March	55	68	56	58.7	60.00	57.26	60.00	53.61	75.4	45.7	89	69	48	44
April	58	68	59	61.0	62.00	58.69	62.00	50.00	80.1	47.0	86	73	50	41
May	61	70	59	62.2	64.00	63.57	66.10	62.00	83.6	52.0	95	75	54	50
June	64	73	59	63.7	65.00	66.43	69.00	63.56	86.6	56.2	102	76	58	54
July	64	75	61	65.2	67.00	68.14	70.00	65.44	84.2	58.6	89	80	61	58
August	63	77	63	66.5	68.00	68.23	69.53	66.00	87.5	59.1	98	82	61	57
September	60	75	61	64.2	65.00	66.04	67.00	65.00	85.4	56.3	94	83	58	54
October	56	64	57	58.5	62.00	63.30	65.00	61.36	83.3	50.4	100	72	55	46
November	49	65	51	54.0	55.00	59.17	60.70	55.00	79.3	45.6	82	76	51	40
December	47	59	50	51.5	52.00	54.27	59.86	52.00	72.7	40.0	79	68	43	33
Spring	......	......	......	60.6	......	59.84	62.00	57.00	......	......	......	......	......	......
Summer	......	......	......	65.1	......	67.60	69.00	66.33	......	......	......	......	......	......
Autumn	......	......	......	58.9	......	62.83	63.80	60.66	......	......	......	......	......	......
Winter	......	......	......	52.8	......	54.01	56.00††	52.25‡	......	......	......	......	......	......
Year	......	......	......	59.3	61.45	61.35	62.50	60.75	......	......	......	......	......	......

	K	O	OO	
	Mean relative humidity (1879).	Average rainfall, 1867-78 (twelve years).	Monthly, seasonal, and annual extremes of rainfall 1867-78 (twelve years).	
		Inches.	Highest. Inches.	Lowest. Inches.
January	71	4.51	14.84	0.25
February	72	3.52	12.32	0.00
March	73	1.16	4.22	0.02
April	67	0.88	2.44	0.00
May	65	0.22	0.74	0.00
June	69	0.02	0.14	0.00
July	72	0.00	0.00	0.00
August	73	0.00	0.00	0.00
September	74	0.00	0.00	0.00
October	70	0.31	1.91	0.00
November	64	1.32	6.53	0.00
December	64	3.74	12.67	0.00
Spring	68.3	2.25	4.88	0.05
Summer	71.3	0.02	0.14	0.00
Autumn	69.3	1.63	6.53	0.00
Winter	......	11.77	20.28	3.35
Year	69.5	15.67	27.83	4.49

* Calculations made according to the Smithsonian formula ¼ (7 A.M. + 2 P.M. + 9 P.M. + 9 P.M.).
** Figures evidently calculated according to the formula ⅓ (7 A.M. + 2 P.M. + 9 P.M.).
† Deduced from Dr. N.'s figures.
†† Winter of 1877–78.
‡ Winter of 1874–75.

and average temperatures for each month and year from January 1, 1871, to December 31, 1879. A correspondence which exists between the maximum and minimum temperatures of the year 1879 in this table, and the figures of Dr. Dimmick in the table first mentioned, shows that the averages are derived by the formula $\frac{7\text{ A.M.} + 2\text{ P.M.} + 9\text{ P.M.}}{3}$ and that the maxima and minima are such as were noted at the regular tri-daily hours of observation; not such as would have been recorded from self-registering instruments. Hence I assume that the same is true of the averages and the maximum and minimum figures of each of the other eight years, 1871–78. The figures of Column K, showing the mean relative humidity for one year, are quoted by Dr. Nelson on the authority of Dr. I. B. Shaw, M.R.C.S., of Santa Barbara. Those of Column O and of Column OO are based on a table presented by Dr. Nelson, which is quoted from records of Drs. Shaw and Tebbetts. This table shows the actual total rainfall of each month and of each year from January, 1867, through December, 1878. A careful examination of the table reveals the fact that, in the course of this period of twelve years, there occurred three winter droughts, viz., in December, January, and February of each of the three winter seasons, 1869–70, 1870–71, and 1875–76. During the first of these three the total rainfall was but 4.35 inches; during the second it was only 5.75 inches; and during the third it was only 3.35 inches. In the case of this last winter season, the excessively small total rainfall of December, January, and February was no doubt, in great measure, compensated by the very exceptionally heavy rainfall of the preceding November (November, 1875), which was no less than 6.53 inches. But in neither of the other two cases of winter drought do we find any compensation. The combined rainfall of October and November, 1869, was only 0.95 inch, while during the nine months of March, April, May, June, July, August, September, October, and November, 1870, the total rainfall amounted to only 3.72 inches. In other words, a winter drought (4.35 inches of rain) was preceded by a rainfall of only 0.95 inch in two months, and followed by a rainfall of only 3.72 inches in nine months. The winter drought of 1870–71 (5.75 inches of rain) was preceded by a rainfall of 1.31 inch in October and November, 1870, followed by nine months, March to November, 1871, having a total rainfall of 4.04 inches. From March 1, 1869, to December 1, 1871—a period of thirty-three months—the total rainfall was only 21.44 inches. On the other hand, in the single month of December, 1871, there fell 6.56 inches of rain; and in January, 1874, there fell 14.84 inches! These facts abundantly establish the truth of what is said concerning the irregularity of the winter rains of California in Blodget's "Climatology of the United States." "They are sometimes much later or much earlier than their average," he tells us, "and sometimes in great excess as well as in great deficiency." As to the rainlessness of the summer season, that is a never-failing phenomenon, as may be seen from the data set down in Column OO. The most extreme case of summer rainlessness recorded in Dr. Nelson's table was that occurring in 1872, when between March 1st and December 1st—a period of nine months—there fell only 0.05 inch of rain.

It is not possible to establish any accurate comparison between the climate of Santa Barbara and that of San Diego or of Los Angeles, based upon the data of the charts for these places, because of the different hours of observation adopted at Santa Barbara, and the shortness of the period of observations upon which some of the data are based. In Dr. Orme's pamphlet we find a brief table (*op. cit.*, p. 7) giving the mean summer and winter temperatures of each of these three places for a period of four years; from which it would appear that, both in winter and in summer, Santa Barbara is the warmest of

the three. Column F of the chart presented in the present article, shows an absence of frost and of very low temperatures at Santa Barbara throughout nine successive winters. But neither this column nor column E can fairly be compared with corresponding columns of the San Diego and Los Angeles charts, because in these latter self-registering instruments supplied the data; in the former such does not appear to have been the case. Dr. Nelson gives an interesting and practically useful table, showing throughout the course of seven years the number of days on which the mercury was observed to fall below 43° (probably either at 7 A.M. or 9 P.M.), and the number of days on which it was observed to rise above 83° (probably at 2 P.M.). This table is presented below.

	1873.	1874.	1875.	1876.	1877.	1878.	1879.
Below 43°............	7	9	4	17	15	23	13
Above 83°	1	6	22	4	10	8	15

Average below 43° F., 12 days; above 83° F., 9¼ days.

The figure 13 in the year 1879 is very likely a misprint, for on referring to his table for 1879, based on Dr. Dimmick's observations, we find that the 7 A.M. observations of January in that year gave a temperature of 41° F. on two occasions, of 40° F. on three occasions, of 39° F. on two occasions, and of 38° F. on one occasion; in February of that year we find three 7 A.M. minima under 43° F. (viz., 42° F., 40° F., and 39° F.); in November two such minima (42° F. on two occasions); and in December of the same year, *i.e.*, the first month of the following winter season, seven such (viz., 42° F. on two occasions, 38° F. on one occasion, 37° F. once, 35° F. once, and 33° F. twice). That is, we get the figure 20 instead of the figure 13 representing the total number of days having a minimum under 43° F. As to the figure 15, showing the number of days, in 1879, having a maximum at 2 P.M. above 83° F., a careful examination of Dr. Dimmick's figures verifies its accuracy. The actual figures for the fifteen days in question were as follows: March, 89° F. once, 84° F. once; May, 92° F. once; June, 97° F. once, 95° F. once, 90° F. once; August, 85° F. once, 84° F. once; September, 86° F. once; October, 90° F. twice, 89° F. once, 88° F. once, 87° F. once, and 86° F. once.

We have now presented all the data at our command which are likely to help the reader toward an accurate understanding of the Santa Barbara climate, at least so far as it has been possible to do so within the just limits of the present article; and the sum and substance of all recorded observations appears to be a demonstration of the fact that Santa Barbara possesses a winter climate as mild in temperature as any in Southern California, perhaps the mildest of all; and that it has (like all other stations lying to the west of the Coast Range Mountains) a very moderate degree of heat in summer, with cool nights, and with temperatures, even at mid-day, which are usually much below those found at that season in the eastern and central portions of the United States. Fogs and winds are the chief blemishes in its winter climate, and it is at that season unsuited for residence by those having a tendency to rheumatism, and is less suitable for most phthisical patients than are the inland stations.

The upper part of the town is the best for residence by those desiring to avoid dampness, and at El Montecito, a suburb two or three miles to the east, there is said to be better shelter against the sea-breeze than at Santa Barbara itself.

THE OJAI VALLEY.—About thirty miles east of Santa Barbara is the Valley of the Ojai, which, according to Dr. Orme (*op. cit.*), is sheltered from ocean winds and fogs. The little town of Nordhoff in this valley has an elevation above sea-level of about 1,500 feet, and stands fifteen miles back from the coast. The Ojai Valley is a resort which seems likely to become one of the most popular in Southern California. Interesting views of Santa Barbara, and rather attractive (although far less instructive) views taken in the Ojai Valley, may be found in *Harper's New Monthly Magazine* for November, 1887.

Huntington Richards.

SANTA FÉ. [For a detailed explanation of the accompanying chart and suggestions as to the best method of using it see article "Climate," vol. ii., pp. 189–191.] Santa Fé, the capital of New Mexico, and the largest town in that Territory, lies at an elevation of seven thousand feet above sea-level, upon the western slope of the Rocky Mountains, the eastern slope of the Valley of the Rio Grande, and, roughly speaking, at a point equi-distant from the crest of the mountain chain and the river. The little river Santa Fé, one of the chief branches of the Rio Grande among those running into the latter from the east, bisects the town. The distance from Santa Fé to the Rio Grande in a "bee line" is about seventeen miles; in a southwesterly direction to the point of junction between the Santa Fé River and the Rio Grande, it

Climate of Sante Fé, N. Mex.—Latitude 35° 41′, *Longitude* 106° 10′.—*Period of Observations, December* 1, 1871, *to June* 15, 1883.—*Elevation of Place of Observation above the Sea-level,* 7,055 *feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	21.1	36.2	26.9	28.0	32.0	22.1	39.5	15.0	76.0	46.0	6.8	–13.0	18	27
February...	24.7	40.5	31.0	32.0	37.0	24.2	44.9	20.7	75.0	48.0	19.0	–3.0	28	23
March......	30.3	49.6	38.5	39.4	47.5	32.4	54.8	28.3	82.0	60.0	25.0	zero	31	31
April.......	36.2	55.8	44.3	45.4	51.2	41.1	58.0	34.3	84.0	67.0	23.0	11.0	21	24
May........	46.7	66.3	54.8	55.9	60.0	52.5	71.3	43.0	89.0	75.0	34.0	24.0	24	28
June........	56.6	76.0	63.6	65.4	68.6	62.2	81.0	51.3	92.0	85.0	53.0	33.0	21	22
July........	60.4	77.4	66.2	68.0	70.3	64.0	83.2	56.8	95.5	86.0	53.0	46.0	22	29
August.....	58.2	75.1	64.5	65.9	68.2	64.3	80.7	55.1	97.0	81.0	53.0	40.0	17	29
September..	49.8	69.7	57.5	59.0	62.5	56.8	74.5	46.6	90.0	74.0	42.0	27.0	28	25
October.....	40.4	60.1	47.8	49.4	52.8	45.7	63.5	37.1	85.0	69.0	29.0	16.0	25	27
November..	29.2	45.8	34.9	36.6	42.7	29.6	49.4	24.6	77.0	56.0	25.0	–11.0	24	27
December..	23.3	39.5	28.7	30.5	33.0	26.4	41.5	17.0	65.0	52.0	10.0	–13.0	18	18
Spring......	......	......	......	46.9	51.8	44.2	......	......	......	......	....	....	......	......
Summer....	......	......	......	66.4	68.2	65.2	......	......	......	......	....	....	......	......
Autumn....	......	......	......	48.3	50.8	44.0	......	......	......	......	....	....	......	......
Winter......	......	......	......	30.1	32.8	27.2	......	......	......	......	....	....	......	......
Year........	......	......	......	47.9	50.2	45.4	......	......	......	......	....	....	......	......

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind, in miles, per hour.
						Inches.	From	
January	89.0	51.7	11.2	15.3	26.5	0.52	N.	6.9
February	78.0	54.0	12.5	11.3	23.8	0.64	N.	7.1
March	82.0	42.9	13.8	12.5	26.3	0.51	S.W.	8.1
April	73.0	35.0	14.7	11.5	26.2	0.57	S.W.	8.8
May	65.0	30.4	15.2	12.4	27.6	0.85	E.&S.W.	8.5
June	59.0	30.5	13.9	13.7	27.6	1.14	S.W.	7.5
July	49.5	46.5	18.4	7.1	25.5	3.41	E.	6.7
August	57.0	50.9	18.0	7.5	25.5	3.01	E.	6.1
September	63.0	43.5	12.7	14.9	27.6	1.25	E.	5.9
October	69.0	41.9	9.9	18.8	28.7	1.02	E.	6.6
November	88.0	49.2	10.9	15.4	26.3	0.91	N.	6.5
December	78.0	50.7	10.8	15.6	26.4	0.65	N.	6.3
Spring	89.0	36.1	43.7	36.4	80.1	1.93	S.W.	8.5
Summer	64.0	42.6	50.3	28.3	78.6	7.56	E.	6.8
Autumn	101.0	44.9	33.5	49.1	82.6	3.18	E.	6.3
Winter	89.0	52.1	34.5	42.2	76.7	1.81	N.	6.8
Year	110.0	43.9	162.0	156.0	318.0	14.48	E.	7.1

is about twenty-three miles. The main chain of the Rocky Mountains near Santa Fé attains a very considerable elevation, and less than thirty miles to the northeast of the town are peaks between twelve and thirteen thousand feet high. Santa Fé does not lie in a valley, but upon a great plateau; "in a wide plain surrounded by mountains," are the words used to describe its location by the writer in the "Encyclopædia Britannica;" while the authors of an army circular, quoted by Dr. W. Thornton Parker in his interesting pamphlet "Concerning the Climate of New Mexico," say that the town is "pleasantly situated on an extensive plateau," etc. We are told by the authors just cited, that although "large pines and cedars are found on the hills toward the mountains . . . the country for miles about Santa Fé is," nevertheless, "destitute of trees," *i.e.*, of trees of any considerable size, although "stunted cedars and pines are very common." They add that "this want of vegetation detracts much from the natural beauties of the town and vicinity." Of the water-supply they say: "The river water is very extensively used for drinking purposes, and is excellent; good water, but a little impregnated with lime, may be obtained by wells at a depth of from ten to forty feet." Of the matter of drainage they remark that although "the natural drainage of Santa Fé is excellent, and is materially assisted by an extensive system of *acequias* or canals around the town, still little attention is paid to the subject, and many of the narrow streets and lanes of the city are excessively filthy." The soil about Santa Fé they describe as "dry, light, and sandy, and yet very fruitful."

I shall attempt no discussion in this place of the claims of Santa Fé as a health-resort. The reader desirous of particular information on this point is referred to Dr. Parker's pamphlet just mentioned. A general discussion of the climate of New Mexico, considered from a sanitary point of view, may be found in the article entitled New Mexico, and in particular toward the close of that article, vol. v., p. 182. In Dr. J. Hilgard Tyndale's papers on "The Climate of New Mexico" (see *Boston Med. and Surg. Journal*, 1883, vol. i., pp. 265 and 313) may be found various tables and data illustrative of the climate of Santa Fé; but the figures presented in the accompanying chart, together with such as stand in Tables A, B, F, and H in the New Mexico article (of which Table F is quoted from Dr. Tyndale), and the data given in the table on page 238 of vol. ii. of this Reference Handbook, will doubtless suffice to convey an abundantly accurate idea of the local climate of this town. *H. R.*

SARANAC LAKE. Saranac Lake lies in the northwest portion of the Adirondack region of New York State, at an elevation of 1,539 feet above the sea-level. Having at command no special climatic data for this resort, and having no comment to make upon its claims as a health-station other than what may be found under the title Adirondacks, in vol. i. of the Handbook, the writer will confine himself in this article to a brief mention of the institution known as the "Adirondack Cottage Sanitarium," which was established near Saranac Lake three or four years ago. This institution, intended for such phthisical patients as, in the opinion of its medical staff, would be likely to derive benefit from a sojourn in the Adirondack country, provides good accommodations and medical supervision, at the exceedingly moderate price of five dollars a week, being supported chiefly by voluntary contributions, and with the object of providing a chance for climatic treatment to persons in moderate or reduced circumstances. The plan wisely adopted in building this institution is the cottage plan, each cottage accommodating from two to four persons, and intended for use simply as a dormitory; the dining-room, general "sitting-room," kitchen, etc., being in the main building, about which the cottages are grouped. This main building is described as "a quaint, irregular, red cottage, with unexpected corners, delightfully original and ample windows, a deep piazza, and a range of offices and store-rooms at the rear." ("The Adirondacks as a Health-resort," by Joseph W. Stickler, M.S., M.D.) The custodian's apartments and four bedrooms for patients are on the second floor of this building.

The site for this institution was admirably well chosen, being a shelf-like plateau "on the shoulder of a hill which overhangs the valley of the Saranac River,"—a "natural terrace on the spur of the hill, with a steep descent of about one hundred feet to the Saranac River in front, and an equally sharp and still higher rise to the crest of the ridge in the rear." (*Op. cit.*) The exposure is toward the southeast. The little plateau commands a fine view of the higher peaks of the Adirondacks, some fifteen miles distant toward the east and southeast. The steep wooded hill-side behind the terrace protects it from the storm-bearing winds of the region. The soil is sandy; the natural drainage facilities are of course excellent. It is much to be desired that similar institutions should be established at other leading sanatoria of the United States. *H. R.*

SARATOGA SPRINGS. *Location and Post-office,* Saratoga Springs, Saratoga County, New York.

Access.—To Albany, N. Y., by the various railroads centring there, thence to the springs by the Saratoga & Champlain Division of the Delaware & Hudson Canal Company's Railroad, extending from Albany north to Montreal, Canada.

Therapeutic Properties.—The characteristic ingredients of the waters of this famous resort are common salt and alkaline carbonates. They are therefore classed as alkaline-saline. The proportion of contained carbonic-acid gas is unusually great, and the waters in great measure owe their popularity to their sparkling appearance and agreeable taste. Altogether there are about thirty springs, six of them spouting. The High Rock, Congress, Washington, Hathorn, Geyser, Empire, and Star springs can be taken as types of the Saratoga waters.

Some are cathartic, some contain iron, sulphur, and iodine. The tonic and cathartic properties of these waters have made them the most popular in America of all adapted to the treatment of catarrhal diseases of the digestive and urinary organs, gall-stones, urinary calculi, jaundice, torpid liver, etc.

Saratoga is situated in the northeastern part of New York State, thirty-two miles north of Albany. Its permanent population is about ten thousand, but this number during the "season" is quadrupled. The streets are wide, well graded, and bordered by large elm-trees. Hotels and boarding-houses abound, and there are many handsome residences. Probably nowhere in the world are there caravansaries constructed upon such a scale as to size and comfort. The attractions at Saratoga are few besides the interest connected with observing the ever changing multitude of fashionable visitors, and listening to the fine music provided at the leading hotels and in Congress Park.

ANALYSIS.—One gallon contains :

	Champion spouting. Prof. C. F. Chandler.	Columbian. Prof. E. Emmons.	Congress. Prof. C. F. Chandler.	Crystal. Prof. C. F. Chandler.	Empire. Prof. C. F. Chandler.	Eureka. R. L. Allen, M.D.	Excelsior. R. L. Allen, M.D.	Geyser. Prof. C. F. Chandler.	Hathorn. Prof. C. F. Chandler.	High Rock. Prof. C. F. Chandler.
	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.
Bicarbonate of lithia	6.247	......	4.761	4.326	2.080	......	......	7.004	7.290	......
Bicarbonate of soda	17.624	15.40	10 775	10.064	9.022	8.750	......	71.232	17.635	34.888
Bicarbonate of magnesia	193.912	46.71	121.757	75.161	42.953	29.340	......	149.343	130.555	54.924
Bicarbonate of lime	227.070	......	143.399	101.881	109.656	41.321	......	170.392	147.226	131.739
Bicarbonate of strontia	0.082	......	trace	trace	trace	......	......	0.425	trace	trace
Bicarbonate of baryta	2.083	......	0.928	0.726	0.070	......	......	2.014	0.972	trace
Bicarbonate of iron	0.647	......	0.340	2.038	0.793	......	......	0.979	0.853	1.478
Carbonate of lime	......	68.00	......	......	......	......	77.000	......	......	......
Carbonate of iron	......	5.58	......	......	......	3.000	3.215	......	......	......
Carbonate of magnesia	......	......	......	......	......	......	32.333	......	......	......
Carbonate of soda	......	......	......	......	......	......	15.000	......	......	......
Chloride of sodium	702.239	267.00	400.444	328.468	506.630	166.811	370.642	562.080	478.722	390.127
Chloride of potassium	40.446	......	8.049	8.327	4.292	......	......	24.634	32.859	8.497
Chloride of magnesium	......	......	......	......	......	......	......	......	......	......
Chloride of calcium	......	......	......	......	......	......	......	......	......	......
Chloride of lithium	......	......	......	......	......	......	......	......	......	......
Sulphate of potassa	0.252	......	0.889	2.158	2.769	......	......	0.318	trace	1.608
Sulphate of magnesia	......	......	......	......	......	2.148	......	......	......	......
Sulphate of soda	......	......	......	......	......	......	1.321	......	......	......
Sulphate of strontia	......	......	......	......	......	......	trace	......	......	......
Sulphate of lime	......	......	......	......	......	......	......	......	......	......
Phosphate of soda	0.010	......	0.016	0.009	0.023	......	......	trace	0.015	......
Phosphate of lime	......	......	......	......	......	......	......	......	......	trace
Biborate of soda	trace	......	trace	trace	trace	......	......	trace	trace	......
Bromide of sodium	3.579	......	8.559	0.414	0.266	......	......	2.212	3.644	0.731
Bromide of potassium	......	......	......	......	......	1.566	trace	......	......	......
Iodide of sodium	0.234	......	0.138	0.066	0.006	4.666	4.235	0.248	0.115	0.086
Fluoride of calcium	trace	......	trace	trace	trace	......	......	trace	trace	trace
Fluoride of lithium	......	......	......	......	......	......	......	......	......	......
Hydriodate of soda	......	2.56	......	......	......	......	......	......	......	......
Alumina	0.458	......	trace	0.305	0.418	0.231	......	trace	0.258	1.223
Silicate of potassa	......	......	......	......	......	......	7.000	......	......	......
Silicate of soda	......	......	......	......	......	......	4.000	......	......	......
Silica	0.699	2.05	0.840	3.213	1.458	0.532	......	0.665	0.700	2.260
Organic matter	trace	......	......	trace	trace	......	......	trace	trace	......
Silicic acid	......	......	......	......	......	......	......	......	......	......
Boracic acid	......	......	......	......	......	......	......	......	......	......
Total	1195.582	407.30	700.895	537.156	680.436	258.365	514.746	991.546	820.844	627.561
Gas.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.
Carbonic acid	465.458	272.060	392.289	317.452	344.669	239.000	250.000	454.082	375.747	409.458

	Kissingen. J. R. Nichols & Co.	Pavilion. Prof. C. F. Chandler.	Red. Prof. J. H. Appleton.	Saratoga A. J. G. Phole, M.D.	Seltzer. Prof. C. F. Chandler.	Star. Prof. C. F. Chandler.	Union. Prof. C. F. Chandler.	United States. Prof. C. F. Chandler.	Vichy. Prof. C. F. Chandler.	Washington. J. R. Chilton.
	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.
Bicarbonate of lithia	5.129	9.486	0.942	......	......	......	2.605	4.847	1.760	......
Bicarbonate of soda	67.617	3.764	15.327	6.752	29.428	12.662	17.010	4.666	82.873	8.474
Bicarbonate of magnesia	70.470	76.267	42.413	20.480	40.339	61.912	109.685	72.883	41.503	65.973
Bicarbonate of lime	40.260	120.169	101.256	56.852	89.869	124.459	96.703	93.119	95.522	84.096
Bicarbonate of strontia	trace	trace	......	......	trace	......	trace	0.018	trace	......
Bicarbonate of baryta	0.992	0.875	......	......	trace	......	1.703	0.909	0.593	......
Bicarbonate of iron	1.557	2.570	......	1.724	1.703	1.213	0.269	0.714	0.052	3.800
Chloride of sodium	238.500	459.903	83.530	565.300	234.291	378.962	458.299	141.872	128.689	182.733
Chloride of potassium	16.980	7.660	6.857	0.357	1.335	9.229	8.733	8.624	14.113	......
Chloride of magnesium	......	......	......	trace	......	......	......	......	......	0.680
Chloride of calcium	......	......	......	trace	......	......	......	......	......	0.208
Chloride of lithium	......	......	......	......	0.562	......	......	......	......	......
Sulphate of potassa	trace	2.032	......	0.370	0.557	5.400	1.818	......	trace	......
Sulphate of magnesia	......	......	......	0.288	......	......	......	......	......	0.051
Sulphate of soda	......	......	......	2.500	......	......	......	......	......	......
Sulphate of strontia	......	......	......	......	......	......	......	......	......	......
Sulphate of lime	......	......	......	0.448	......	......	......	......	......	......
Phosphate of soda	......	0.007	trace	......	......	......	0.026	0.016	trace	......
Phosphate of lime	......	......	trace	......	trace	trace	......	......	......	......
Biborate of soda	......	trace	......	......	......	......	trace	trace	trace	......
Bromide of sodium	1.800	0.987	......	......	0.630	0.565	1.307	0.844	0.990	......
Bromide of potassium	......	......	......	......	......	......	......	......	......	0.474
Iodide of sodium	0.042	0.071	......	......	0.031	20.000	0.039	0.047	trace	2.243
Fluoride of calcium	trace	......	......	......	trace	......	trace	trace	trace	......
Fluoride of lithium	......	trace	......	......	......	......	......	......	......	......
Hydriodate of soda	......	......	......	......	......	......	......	......	......	......
Alumina	trace	0.329	2.100 *	0.380	0.374	......	0.324	0.094	0.473	trace
Silicate of potassa	......	......	......	......	......	......	......	......	......	......
Silicate of soda	......	......	......	......	......	......	......	......	......	......
Silica	1.280	3.155	3.255	......	2.561	1.283	2.653	3.184	0.758	......
Organic matter	trace	trace	......	......	......	......	trace	trace	trace	......
Silicic acid	......	......	......	1.460	......	......	......	......	......	1.500
Boracic acid	......	......	......	......	trace	......	......	......	......	......
Total	444.627	687.275	255.680	656.911	401.680	615.685	701.174	331.837	367.326	350.227
Gas.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.
Carbonic acid	432.634	332.458	....	212.000	324.080	407.550	384.969	245.734	383.071	363.770

* Alumina and sesquioxide of iron.

The High Rock is the oldest spring, its medicinal qualities having been known to the Indians, and by them shown to the whites as early as 1535. Derick Scowton built the first log-cabin here in 1773, and in 1784 General Schuyler erected the first frame-house and made other improvements toward rendering the place more accessible and providing for visitors.

The season extends from the middle of June to September. During July and August the weather is apt to be excessively hot. Yet the air is pure and is generally acknowledged to be tonic. Shade-trees on the streets, in the park, and in the extensive and attractive courtyards of the leading hotels, in a great measure temper the atmosphere and compensate for the absence of a cooler climate. *Geo. B. Fowler.*

SARCOMA. In defining the various tumors of which we have treated in this work, it was possible to compare them with some normal tissue, either in the character or in the arrangement of the cellular elements. We come now to the consideration of a tumor most forms of which do not agree, either in structure or in the character and arrangement of the cells, with any of the tissues of the adult body. The sarcoma has most similarity in structure to the connective tissue, and its affinity to this is still more clearly shown by the fact that it always originates in this tissue. The chief difference between the sarcoma and the other connective-tissue tumors is that the connective tissue which forms the type of the sarcoma is represented, not by the adult, but by the embryonic form of this tissue. The different varieties of sarcoma may be said in a general way to represent the different phases which the embryonic connective tissue passes through in the course of development. This difference between the embryonic and the adult connective tissue is chiefly found in the greater abundance of cells in comparison to the formed material, the intercellular substance; and a similar difference exists between the sarcoma and the fibroma. In the fibroma we have a tumor composed of a tissue which in nowise differs from the adult connective tissue, and which cannot be distinguished from it, macro- or microscopically. The same is true of the osteoma and chondroma. The tumors are typical. The sarcoma may not differ from the fibroma, save in the number of its cells, nor from the osteoma or chondroma, save in the fact that the bone or cartilage in the tumor is atypical, as compared with the adult tissues, and resembles that formed in the first stages of the evolution of the skeleton. We may have different species of sarcoma, which are more unlike each other than two tumors of wholly different names.

The tumors which are now included under the term sarcoma were formerly known under a great variety of names. The name sarcoma is a very old one, and was used to describe all manner of fleshy growths (σάρξ, flesh). Galen described under this name fleshy polypi of the nasal cavity, and afterward all sorts of fleshy growths; and later authors used the term to describe all growths which had the appearance and consistency of muscular tissue. Still later the conception was extended until, at the beginning of the present century, it came to include every sort of tumor which had not a cystic structure, or was not extremely hard, or had not an especial tendency toward ulceration. The influence of Abernethy was felt in this; he proposed to make a very large group of tumors, which received the general name sarcoma, and which was further subdivided, according to general appearances and clinical course, into a number of species. Only the cystic tumors, the exostoses, and cancers were left out. As soon, however, as the tumors began to be studied histologically, those for whose tissue a type could be found in some one of the adult tissues were separated from what had been known generally as sarcomas, and an attempt was made to abolish this name. Still, it was found that many tumors did not agree exactly with the forms of connective tissue, though they were evidently derived from it. Lebert, in France, designated the most common of the sarcomas, and the one most frequently taken as a type of the tumor, the spindle-cell sarcoma, fibro-plastic tumor. Robin separated from the general group certain tumors which, though having much analogy with the fibro-plastic tumors, yet in their structure more nearly approached that of the embryonic tissues, and to these he gave the name embryo-plastic. In England, Paget, studying the tumors more from a clinical than a histological stand-point, found certain tumors which, though similar in appearance to the fibromas, differed from these by their greater malignity, as shown by a tendency to return after removal. To these he gave the name of recurrent fibroid. Paget named other tumors, from the similarity of their structure to the marrow of bones, myeloid tumors. We owe to Virchow the first scientific classification of these tumors; and his views, as expressed in his "Geschwülste" (1864), have since then undergone but slight modifications.

We will first consider the sarcoma as a single tumor, then under separate heads the various varieties. The sarcoma, in general, is distinguished from all other tumors by the abundance of its cells, and the diagnosis of the particular species is in great part made from the character of these cells. In the case of the simple tumors of the histoid group, as the fibroma, myxoma, etc., the diagnosis is made, not so much from the character of the cells as from the tissue which they produce. In the carcinoma and other tumors of the epithelial type, the diagnosis is made, not only from the character of the cells but by their grouping. The great strength of Virchow's description of the sarcoma lies in his comparison of the tumor to embryonic tissue. Billroth does not agree with him in this, but considers the sarcoma-tissue as most similar to embryonic muscular tissue. This applies especially to that variety of sarcoma which is composed of spindle-cells. The type of the sarcoma-tissue may also be found in the adult tissues, in some pathological conditions. The tissue covering the floor of an ulcer, the granulation-tissue wherever found, is similar to the tissue of some of the sarcomas. This granulation-tissue passes through the same steps in the formation of connective tissue as does the embryonic tissue. In its earliest form it is composed almost entirely of cells which present some differences of form, and whose general character is represented by a round cell about the size of a leucocyte, with a relatively large nucleus. Not infrequently large protoplasmic masses, containing many nuclei, may be found in this tissue. The blood-vessels are peculiar in that, in many cases, they appear to represent nothing but channels surrounded by cells, and are altogether lacking in a supporting meshwork of connective tissue. Granulation-tissue varies in some degree in the various tissues in which it arises; that coming from the marrow of bones, as in cases of fracture, etc., is similar to the embryonic marrow. We may have represented by it not only the general type of the sarcoma, but also some of its distinct species. The difference between the sarcoma and the inflammatory granulation-tissue is to be found, not in the histological character of each but in the termination to which each tends. When the granulation-tissue is produced in consequence of a wound or a chronic disease of the bone or articulation, it never passes beyond a certain point of growth, tends to the production of a typical tissue, and ceases to be when the conditions which favored its development no longer exist. In all cases a tendency to, or a beginning production of, a typical formed tissue can be seen in some part of the granulations. In the sarcoma, on the other hand, there is no such tendency to the production of tissue, but the cells simply increase in numbers. The character of the cells of a sarcoma is but slightly influenced by its seat; every variety of cell may be found in tumors arising from the subcutaneous cellular tissue.

The close connection of the sarcoma with the typical connective-tissue tumors is further shown by the formation of mixed forms with these. In a fibroma the whole tumor, or certain parts of it, may contain more cells than can be regarded as typical for fibrous tissue; in other words, it approaches the type of connective tissue found in the embryo. This connection with sarcoma is expressed by the compound name fibro-sarcoma, myxo-

sarcoma, etc. Virchow says that a tumor may also represent a mixed form between the sarcoma and carcinoma, in which certain parts are sarcomatous and others carcinomatous. Such tumors he has named sarcoma carcinomatosum, and he ascribes to them the malignity of both the sarcoma and the carcinoma. He does not think that in such cases the tissue of the sarcoma passes over into that of the carcinoma, but that they both develop simultaneously from the same tissue, growing like two branches of the same stem. When we regard the carcinoma as a pure epithelial tumor, and the sarcoma as a connective-tissue tumor, such combined forms must seem extremely improbable, and the tumors in which such a combination appears to exist will be found, on careful examination, to be either carcinomas with a stroma very rich in cells, or sarcomas in which the arrangement of the cellular elements resembles somewhat the alveolar structure of the carcinoma, the alveolar sarcoma of Billroth.

Regarding, then, the sarcoma as a pure connective-tissue tumor always arising in this, it will be seen that it holds the same relation to this tissue that the carcinoma holds to the epithelial tissue. Both are atypical tumors, the sarcoma showing this departure from the regular type of connective tissue by the abundance of its cellular elements, and the carcinoma showing its departure from the type of epithelial tissue by the number and arrangement of its cells. Each may begin as a typical tumor. The sarcoma may first appear as a fibroma, and then, by an excessive development of cells, without any further development of formed tissue, become a sarcoma. The carcinoma may in like manner begin as an adenoma, and become atypical by the epithelial cells forming solid cylinders and growing into the connective tissue. There may be the mixed form of adeno-carcinoma, just as there may be the mixed form of fibro-sarcoma. The sarcoma bears the same relation to the fibroma that the carcinoma bears to the adenoma, but between the sarcoma and the carcinoma we have not only a morphological, but a histogenetic, difference.

No one sort of cell can be regarded as typical of the sarcoma. Almost every variety of cells may be met with, and even in the same tumor there may be found round cells similar to the granulation-tissue, spindle-shaped, and giant cells. The form of the cells, in great part, depends upon the physical conditions to which they are subjected in the tumor. When the intercellular substance is relatively abundant, and fluid or semifluid, the cells are subjected to the same pressure in all directions, and they are then round. When the intercellular substance exists in but small amount and is more or less solid, the cells are then pressed against one another, and they take various shapes. If the pressure is exerted laterally they become elongated and spindle-shaped. On such cells facets can often be seen, caused by the pressure of opposing surfaces. The different characters of the cells may best be studied on small pieces of the tumor which have been macerated for a long time in one-third water and two-thirds alcohol, as recommended by Ranvier, or in Müller's fluid. The latter method gives in many cases excellent results.

Spindle-cells are found more often than any other sort of cells in sarcomas. These are long cells terminating in long pointed extremities. In the middle the cell is swollen and contains a single nucleus, and rarely more than one. The nucleus is more refractive than the remainder of the cell, and often contains a bright nucleolus. In some cases more than one process is given off from an extremity, giving the cell something of a stellate appearance. These cells may vary a good deal in character in the different tumors. In many cases cells are found which present a spindle appearance only when viewed in profile; on the side they appear as flattened epithelial scales. These cells are formed by pressure on the sides. Stellate cells are often found with long, branched processes, which may communicate with neighboring cells. The round cells vary much in size and general character; some are found which are about the size of white blood-corpuscles, and contain a nucleus which is very large in comparison with the cell. In other tumors large oval cells, closely resembling epithelial cells, are found, and between these two extremes there may be numerous other varieties.

Whatever may be the character of the sarcoma-cells, they are always in the closest connection with the connective tissue. Even in those tumors which are richest in cells there is always a certain amount of intercellular substance between the cells, and there is not the same sharp contrast between the cells and the stroma which carries the blood-vessels, that exists in the epithelial tumors. In these the cells are arranged in groups like the glandular organs, with the stroma surrounding the groups of cells, but not entering into them. This is a diagnostic point of the greatest importance between the sarcoma and the carcinoma. Even in the case of the alveolar sarcoma the separation of the cells into alveoli is only apparent, and on closer examination it will be found that small masses of connective tissue, and even blood-vessels, enter into the alveoli.

Of late numerous growths, which were formerly considered under the sarcomas, have been removed from the list of true tumors. This is the case with the pearly nodules which are found on the serous surfaces of cattle, and which Virchow placed among the sarcomas. They have been shown to be identical with tubercle-nodules, and to be due to the specific virus of tuberculosis. The same thing is true of actinomycosis. Before it was known that this disease was caused by a definite organism, the large tumor-like masses which it produces in the jaws of cattle were classed with the sarcomas, as a species of osteo-sarcoma, and it is probable that there may be other tumors, now classed with the sarcomas, which will be shown to be due to a specific virus.

All sarcomas are very vascular, and, as a rule, only the larger vessels have any considerable amount of connective tissue around them. The smaller vessels are in direct contact with the cells, they are more voluminous than vessels of a similar character in normal tissues, and their walls are composed of cells which in many cases are similar to those of the tumor. On section they appear simply as spaces surrounded by the tumor-cells. They are similar to the vessels found in granulation-tissue. The close connection between the cells of the tumor and the blood-vessels is of great importance, and explains the course taken in the formation of metastases.

In forming a classification of sarcomas, the only basis that we have is the character of the cells. As said before, there may be different forms of cells in the same tumor, but one type will be found to be dominant. When divided into different species in this way, it will be found that, though there are a good many points of similarity in histological character, a study of the clinical features of each species will make these differences in structure still more evident. Some of the forms into which they may be divided will be found to be of much more clinical importance than others. The classification which we have adopted, one based principally on the character of the cells, is as follows:

1. Round-cell sarcoma syn.; granulation-sarcoma, sarcome encephaloïde, lympho-sarcoma, embryo-plastic tumor. A tumor composed of a tissue similar to that of the upper layer of granulations. The cells are round, and there is a very small amount of intercellular substance between them.

2. Spindle-cell sarcoma; syn., sarcome fasciculé, fibroplastic tumor, recurrent fibroid. A tumor composed of spindle-cells which are generally arranged in bundles. The intercellular substance is small in amount.

3. Myeloid sarcoma. A tumor composed of cells similar to those in the bone-marrow, and among these large multinuclear, protoplasmic masses known as giant-cells.

4. Osteo-sarcoma. A tumor somewhat resembling the myeloid sarcoma, but in which there is a tendency for the embryonic tissue to organize and form more or less complete bony masses.

5. Melano-sarcoma. A tumor whose cells contain a dark-brown or black pigment, which differs from the pigment formed from blood-extravasations.

6. Alveolar sarcoma. A tumor composed of cells often resembling epithelium, and having, in the arrangement of the cells into alveoli, some similarity to the carcinoma, but with the difference that the separation of the tissue into cell-masses and connective tissue is not absolute as in the carcinoma.

7. Angio-sarcoma. A tumor which combines an extensive new formation of blood-vessels with an active growth of the cells forming their walls.

Some authors have subdivided the sarcomas still further, making twelve or more species. The division here given will embrace most of the forms of sarcoma. The mixed forms, with other tumors, have already been treated of. See Fibroma, Myxoma, etc. Any classification that can be made, either from the histological or from the clinical features, is at best an artificial one, and cases are often found in which it is difficult to say to which one of the species mentioned it belongs.

Round-cell sarcoma. The cells of which this tumor is composed may be very small, resembling those found in granulations, with a nucleus almost entirely filling the body of the cell, or may be larger, similar to some epithelial cells. They are round and surrounded by an inter-cellular substance which is very soft or semi-fluid. On section of the fresh tumor a small amount of juice, more transparent than that which comes from a carcinoma, escapes; but after the tumor has been kept for from twelve to twenty-four hours, and the inter-cellular substance has been softened by cadaveric changes, this juice is more abundant. It is probable that the inter-cellular substance is not naturally fluid, but of a jelly-like consistency; or if fluid, it is held in the meshes of the tissue just as the fluid is retained in dropsical tissues. When the fresh fluid is examined large numbers of cells will be found in it. In many cases the amount of fibrillar connective tissue is so small, that it is only by careful shaking and brushing the section that it becomes visible. Some of this connective tissue is undoubtedly newly formed, but part is the old connective tissue of the place of origin of the tumor, simply pushed apart by the rapidly-growing cells. Some spindle-shaped cells are always seen, either around the larger groups of round cells or along bands of connective tissue. When a thin section has been shaken for a long time in a test-tube with water, most of the cells will be washed away, and if the section has been examined before this, one will be surprised at the amount of connective tissue which is now visible. There may be an almost perfect reticulum, which can surround every cell in much the same way as in a lymphatic gland. The blood-vessels are always very large and abundant. They seldom have normal vascular walls, and on section appear as spaces between the cells. Only the larger ones are surrounded by any connective tissue. Along these vessels, and generally throughout the tumor, blood extravasations are common. The connection of the tumor with the surrounding tissues is a very close one, and it is often difficult to say just where the tumor ends. The most striking resemblance between this tumor and an inflammatory focus is often seen. These round-cell sarcomas are very malignant; they grow rapidly and diffusely, invading the surrounding tissues, and produce metastases. When the cells are large and have more the appearance of epithelial cells, the malignant course is not so pronounced. Most of the tumors known as encephaloid come under the head of round-cell sarcomas. The term encephaloid refers simply to the pulpy, brain-like character of the tumor, due to the number of the cells and the softness of the material between them.

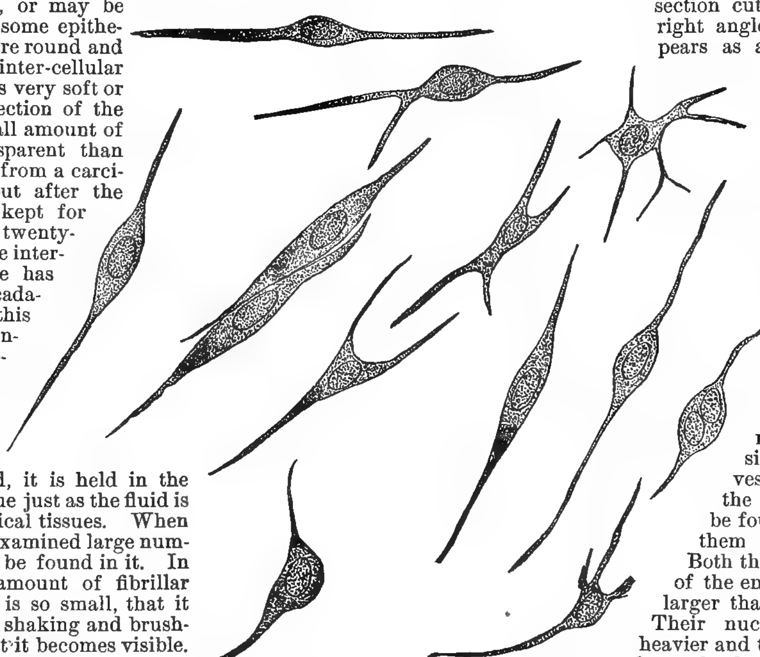

FIG. 3376.—Cells from a Spindle-cell Sarcoma of the Periosteum; isolated by maceration in Müller's Fluid. × 300.

The spindle-cell sarcoma is more frequently met with than any other form, and this tumor has been generally regarded as the type of the sarcoma. The tissue of the tumor is arranged in fasciculi, and this is so evident that it has given rise to many of the names which the tumor bears. This arrangement into fasciculi can best be studied by roughly tearing apart tumors which have been hardened in alcohol. The trabeculæ are composed of spindle-cells and fibrils, all running in the same direction. Often several of these fasciculi seem to arise from the same point, and take a more or less spiral course. They run through the tumor in every direction, and are sharply separated from one another. Sections made through the tumor cut them in every plane. When the section cuts one of them at a right angle, it no longer appears as a spindle, but as a round cell. A blood-vessel generally traverses the centre of one of these bands, and in its walls every transition between the thin wall of a capillary and the thicker wall of an artery or vein can be seen. The smaller of them consist of endothelial tubes, the cells composing which can be seen without treatment with nitrate of silver. Besides these vessels passing through the bundles, others will be found which surround them like a long spiral. Both the cells and the nuclei of the endothelium are much larger than in normal vessels. Their nuclei, especially, are heavier and thicker, they project above the level of the cells, and are seen in the lumen of the tube as slight elevations. As a rule, these blood-vessels are much wider than vessels of a corresponding structure in normal tissues. Either the entire vessel may be wider, or there may be dilatations at intervals, which may reach a considerable size. The spindle- or oat-shaped cells, of which the tumor is principally composed, early attracted attention when the histological structure of tumors began to be the subject of systematic study. For a long time they were considered as characteristic of the sarcomas and of the malignant tumors in general. These cells are not always pure spindles in shape, but often show various transitions approaching the stellate form. They consist of an elongated mass of protoplasm, which at each extremity runs out into a long, thin process. Sometimes two or more processes are given off from a single extremity, and these in turn may have lateral processes. The surface of the cell is rarely perfectly round and smooth, but is indented in various ways, and may be flattened into a membranous form. The protoplasm of the cell is finely granular, and more refractive than that of the white blood-corpuscle. Occasionally one or more fat drops are found in a cell. The nuclei are ordinarily visible without the aid of acetic acid or any coloring agent. They lie in the

middle of the cells and occupy the entire body of the cell at this point. Rarely more than one nucleus is found in a single cell. The cells are not always of the same size, even in the same tumor. The smallest of them are about 15 μ long and 5 μ broad, while in other cases they are 100 μ long and 15 to 30 broad. This difference in the size of the cells has led to a division of the tumor into large and small spindle-cell forms. In general the cells are smaller in those tumors which have the most rapid growth, or in those parts of a tumor where the growth is most recent. The cells all lie in the same direction in the bundles, dovetailed into one another, with the largest part of one cell in contact with the smallest part of its neighbor. In a perfectly fresh tumor it is difficult to separate the cells from each other. A certain amount of fibrous tissue is always to be found in these tumors, and even in the bundles where the cells lie thickest careful observation will show some fibrils between the cells. These fibrils often appear to be in direct continuity with the cells. The name fibro-plastic was given to this tumor on account of the supposed tendency of the spindle-cells to form fibres. Bands of connective tissue in which the cells are very numerous, are sometimes found between the larger cell-bundles. The slower the growth of the tumor, the more connective tissue is found in it. The spindle-cell sarcomas vary much in density, but are always much firmer than the round-cell form. Some of them are fully as hard as a myoma, and on section resemble this very much. The firmness of the tumor depends upon the amount and character of the intercellular substance. In the fresh state the cells are difficult to isolate, and on scraping the cut surface a clear, transparent fluid, containing but few cells or fragments of cells, will be obtained.

The myeloid sarcomas are soft tumors whose tissue is similar to that of the embryonic bone marrow. The cells lie in close relation with each other, and the intercellular substance is small in amount and more or less fluid. Some of the cells are small and spherical, like those of embryonic bone marrow, and like the early embryonic cells in general. They have little protoplasm in comparison to the size of the nucleus, and are similar to those described in the encephaloid sarcoma. Sometimes numerous spindle-cells are found, but these have not the definite arrangement into bundles that is found in the spindle-cell sarcoma, and their processes are not so long. There are other cells, which though sometimes met with in other species of sarcoma, more properly belong here. These are large protoplasmic masses containing a great number of nuclei, frequently one hundred or more, and have received the name of giant cells. They are found in considerable numbers in embryonic bone marrow, but never reach the size that is met with in tumors. They may be round, or oblong, or irregular in shape, and provided with numerous processes. The nuclei are sometimes arranged at one or both ends of the cell, or may be packed closely together in the middle. They are rarely scattered evenly through the cell-substance. The typical arrangement of the nuclei along the periphery of the cell, with their long axes pointing to the centre, which is so often found in giant cells elsewhere, notably in tubercles, is seldom found here. These cells may fall from their places in sections, and the empty spaces which were occupied by them may give the tissue an alveolar appearance. It is not uncommon to find them in great numbers in one part of the tumor, while other parts may not contain them at all, or only isolated examples scattered here and there in the tissue. The nuclei of these cells are large and refractive, and in most cases can be seen without the aid of any reagent. The cell-substance itself is composed of a thick, finely granular material, which frequently has a slight yellowish or greenish tinge; in these cases the cell may be so dense that the nuclei only appear when the protoplasm has been rendered more transparent by acid. The size which these cells frequently attain fully justifies their name. They may reach a diameter of one-fifteenth to one-tenth of a millimetre or more, and can be seen with the unaided eye. Although most frequently found in the myeloid sarcoma, they are often found in the other varieties also, especially in the spindle-cell sarcoma. The myeloid sarcomas are almost always seated in a bone, and originate in the marrow. They gradually destroy the bone, but as the tumor grows a new capsule of bone is formed around it.

Osteo-sarcoma. See Osteoma.

Alveolar sarcoma. This name was first used by Billroth to designate certain sarcomas whose histological structure somewhat resembled the carcinomas, in that the cells were grouped together into alveoli. So striking is the similarity to carcinoma, that Billroth himself says that in many cases he is unable to make the differential diagnosis. It has been contended by many pathologists that the term was a misnomer, and that any tumor of such a structure must be a carcinoma. However similar the structure of the two tumors may be, a careful investigation will always show points of difference. In the strictest sense, no sarcoma has the alveolar structure of the carcinoma. Still, tumors which certainly originate in the connective tissues, and which, from their general structure, must be regarded as connective-tissue tumors, are occasionally met with, which, on a superficial examination, appear to have an identical structure with carcinoma. The cells are round or irregular in shape, are very similar to epithelial cells, and are arranged in groups which are surrounded by connective tissue. These groups of cells may be smaller or larger in the different tumors, and the connective tissue also varies in amount. In all cases the tissue around the groups of cells is richer in cells than ordinary connective tissue, and may be composed of spindle-cells. On closer examination it will be found that the connection between these groups of cells and the tissue around them is much closer than is the case in carcinoma. When thin sections are made of carcinomas which have been hardened in alcohol, it will be found that in many cases the groups of cells have fallen out in the manipulation of the specimen, or have shrunken, leaving the connective tissue around them as a sharp, clear line. On shaking such sections in a test-tube with water, or carefully brushing them, it is possible to remove all the groups of cells, leaving the connective-tissue framework intact. In specimens which have been injected, it is never possible to follow a blood-vessel into an alveolus. In the alveolar sarcoma the case is different. It is never possible to remove the cells as completely and easily as can be done in a carcinoma. After brushing the specimen to remove as many of the cells as possible, it will be found that fine filaments of connective tissue enter into the apparent alveolus, and in some cases every cell is enclosed in a delicate meshwork. This is much better seen when the section is examined in water, as the fine fibrils are more refractive in this than in any other medium. The difference between the two tumors is also apparent from a careful macroscopic examination. On scraping or squeezing the cut surface of an alveolar sarcoma, a juice will be obtained which is never so abundant as that which comes from a carcinoma so treated, and on microscopic examination of this juice, numerous cells of various shapes and sizes will be found in it. The compact groups of cells so often found on examination of the juice from a carcinoma, and which evidently represent the contents of an alveolus, will not be found. These tumors are very vascular, the connective tissue between the alveoli contains numerous large blood-vessels, and fine capillaries given off from these penetrate the alveoli. The tumor is frequently found in the testicle, and the soft and rapidly growing tumors of this organ generally belong to this variety.

The most malignant of the sarcomas, and in many respects the most malignant tumor that is met with, is the pigmented sarcoma, the melano-sarcoma. This is characterized by the presence of a dark pigment, similar to that in the choroid of the eye, in the cells. The melanotic sarcomas, as a rule, appear only in places where some pigment in the connective tissue is normally present, as in the choroid of the eye and in the skin; they have also been seen in the lymphatic glands. Other sarcomas containing pigment may be mistaken for these

tumors. Hæmorrhages are common in every variety of sarcoma, and the blood-pigment which results from this and is taken up by the cells may be mistaken for the essential melanotic pigment. In these cases, besides the pigment in the cells, some will be found free. This free pigment either results from the breaking down of cells which contained it, or it is formed by a metamorphosis of the blood-pigment which has taken place, not in the cells, but in the interstitial tissue. In both this accidental and the essential autochthonous pigmentation, the pigment-granules may be brown or dark-brown, and in some cases it is not easy to decide, except by a careful examination, what the nature of this pigment is. In the melanotic sarcoma in course of development, all of the cells are not impregnated with pigment, and in no case do all the cells of the tumor contain this pigment in equal amount. As a rule, a section of such a tumor will show various zones of coloration, the color being deeper in those portions of the tumor which must be regarded as the oldest. The oldest portions are black, and the younger portions on the edge of the growth may be only brownish or not pigmented at all. Although this partial pigmentation is the rule, some tumors are found which are black in their whole extent. The pigment-granules are most often disposed around the nucleus, but they may fill up the entire cell. No pigment is ever found in the nucleus. The pigment which results from a metamorphosis of blood coloring matter usually has a reddish tinge, which is absent in the true melanotic pigment. The cells of these tumors have no particular arrangement or form. The tumor may present the most typical appearance of a spindle-cell sarcoma, but as a rule they belong to other forms, the arrangement of the cells into alveoli being especially frequent. When such tumors are scraped a blackish, often inky, fluid is obtained, which contains many pigmented cells, but also free pigment-granules in great numbers. These free granules have an active molecular movement. The source of this pigment is a subject which has for a long time occupied the attention of pathologists. In the consideration of this question, the fact that the tumor rarely originates in tissues except those in which pigment is normally present, is of the first importance. As we have said before, the favorite places of origin are the choroid of the eye and the skin. It does not appear primarily in the other pigmented tissues of the body, as in the liver, the supra-renal capsules, and the seminal vesicles. The pigment is very similar to that found in the connective-tissue cells of the corium in the negro race. Virchow believes that the pigment is formed in the cells themselves as the result of their own metabolism. This view is the one in favor of which most facts speak, and is the view most generally accepted. Gussenbauer, on the other hand, believes that the pigment is formed directly from the blood-pigment, and calls attention to the frequency with which hæmorrhages are found in such tumors. Most strongly against this view speaks the fact that the secondary tumors always show the same sort of pigmentation as do the primary. In no tumors are such minute metastases found as in these, some of the secondary growths being composed of but a few dozen cells, and being evidently of such a recent date that sufficient time would not have been given for the formation of pigment from blood extravasation, even were extravasation present. Besides this, blood extravasations cannot be said to be more common in the melanotic sarcoma than in any other. Akerman, in his interesting monograph on sarcoma, has called attention to the situation of the pigment in Addison's disease, and of the pigment which is often found in the skin of certain parts of the body of dark-skinned people. These pigment-cells lie in the neighborhood of the small vessels of the skin, are of long spindle shape, and contain a diffuse or granular brown coloring matter. He supposes that these pigment-cells are specific and have no connection with the ordinary cells of the connective tissue, and that the melanotic tumor may arise from a proliferation of these cells. In the skin the tumor most often originates from small, congenital, pigmented nævi. Many of these, which are to all purposes perfectly benign, show on section the most typical sarcomatous structure. In connection with these tumors, Virchow calls attention to the melano-sarcomas in horses. It is a well-known fact that white and gray horses are especially subject to these tumors, which appear principally on the tail or around the anus. The tumors have not the malignant course that similar tumors have in man, and ordinarily do not reappear after com-

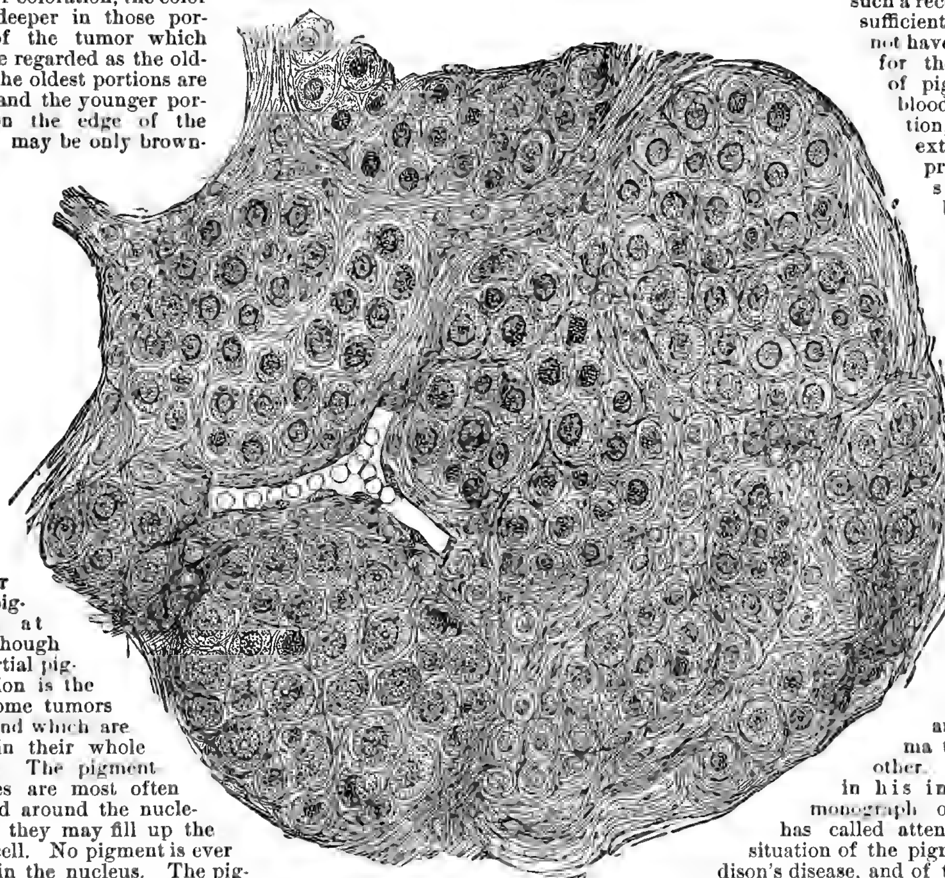

FIG. 3377.—Section of an Alveolar Sarcoma of the Testicle. × 400.

plete excision. A tendency to the development of these tumors is transmissible in high degree, especially by the stud; the offspring, both male and female, especially those of a whitish color, being liable to it. Virchow sees in the absence of color in such horses a weakness or lack of resistance in the skin.

The angio-sarcoma is a tumor formed by an extensive development of blood-vessels and a sarcomatous growth of their walls. The tumor appears to be made up of long filaments, which are loosely attached to each other and may be isolated for considerable distances. Each filament contains a blood-vessel in its centre, and around this an extensive formation of cells. There is no distinct wall to the vessel, save that formed by the tumor cells. The cells are distinctly epithelial in appearance, and are divided into groups by the formation of capillaries. This tumor may develop in any part of the body, grows rapidly, reaches a large size, and is very malignant. The metastases which result from it have the same general structure as the primary tumor, but the arrangement of the blood-vessels with the cells surrounding them is not so well marked.

After this description of the histological structure of the different forms of sarcoma, we will consider the tumor more as a whole, especially its macroscopic characters, most frequent seat, clinical course, etc.

The growth and the general clinical characters of the sarcoma are so different in the several forms that we can find in this group of tumors representatives of completely benign as well as of the most malignant growths. Beyond doubt, in this regard, the separate varieties of the tumor have individual characteristics. The pigmented sarcomas may be regarded as the most malignant of tumors, not only on account of their local destructiveness, and rapid and unlimited growth, but also from their tendency to form metastases. The small-cell encephaloid varieties are but little behind these in malignity. The osteo-sarcomas come next, and the spindle-cell and myxo-sarcomas are in general only malignant locally. The spindle-cell sarcoma is the more malignant the smaller are its cells, and the more numerous they are in proportion to the amount of intercellular substance. As a rule, it does not form metastases, but cases in which extensive secondary growths appear are not uncommon. When the sarcomas are compared with the other tumors of the connective-tissue type, it is evident that they have a much greater malignity, and this is shown in all by their tendency to return after extirpation. This tendency to local return, even in cases in which the entire tumor and much of the surrounding apparently healthy tissue have been removed, shows that the sarcoma is not a sharply circumscribed growth. The microscopic investigation of the periphery of sarcomatous tumors will often show that the tumor-cells have entered much more deeply into the surrounding tissue-spaces than is apparent on a mere macroscopic examination. The cells not only have an extreme degree of proliferative energy, but the tissue of the sarcoma, which is so much looser than that of any typical connective-tissue tumor, favors this outward growth of the cells. In addition to this direct outgrowth of the cells into the tissues, it is very probable that the cells of many sarcomas have the power of amœboid movements. This would explain the presence of small foci separated by a greater or less interval from the parent tumor. Virchow advances the view that the sarcoma cells can excite the cells of the tissues with which they come in contact to a similar growth. This can take place both about the original tumor and in those places where the cells may be carried by the blood and lymph currents. Most of the recent authors do not accept this view as to the mode of formation of secondary tumors, but believe that these result from a direct growth of the cells or collections of cells which have been carried from the tumor and deposited in distant organs. The power of the sarcomas to produce secondary metastatic nodules in the most different organs is not confined to any special species, though some show a much more decided tendency in this direction than others. In some cases the secondary nodules are of such small size, and appear in so many places in the body, that the condition is known as sarcomatosis. These nodules, from their very small size, may be mistaken for miliary tubercles. The path of the metastases is almost always along the blood-vessels, the sarcoma in this again contrasting with the carcinoma, in which metastases follow the lymphatics. Although this mode of infection is most common in sarcoma, there are exceptions in which the lymph-glands are early infected. This is notably the case in sarcoma of the bones. The course that the metastasis usually takes is easily explained, when we consider how intimate the relation is between the cells of the tumor and the blood-vessels, the latter being in many cases without essential walls, and representing little more than channels between the tumor-cells. It is by no means rare to find a sarcoma growing directly into a large vein, and it may extend in this for a considerable distance as a long, fleshy polypus, moving freely in the blood-stream, and apparently nourished by the surrounding blood. Billroth mentions a case in which a sarcoma of the testicle grew into the spermatic veins, some of its cells being carried thence through the inferior cava into the heart, and producing numerous metastases in the lungs. As we should suppose, metastases are most commonly found in the lungs, and next in the order of frequency come the spleen, the kidneys, and the liver. Infection of these organs is generally secondary to infection of the lungs. The metastases are often much larger than the primary tumor, and are the most frequent cause of death.

The clinical importance of a sarcoma does not depend altogether upon the histological structure. The seat of the tumor is of great importance, for it is evident that, when seated in an organ whose functional activity is necessary for the life of the individual, the tumor may be very dangerous, even when it does not show any special tendency to the formation of metastases. The glio-sarcomas of the brain are malignant, though they are always confined to this organ. It is also well known that the mediastinal tumors are dangerous in consequence of the pressure on the great blood-vessels which they exert. This primary danger of the tumor in great part depends upon the rapidity of its growth. In general, it may be said that the growth is most rapid, and the tendency to metastases strongest, in those tumors in which the cells are smallest and most abundant. This growth may be restricted in various ways by the local relations of the tumor. The sarcomas of the bone grow slowly, and do not produce metastases as long as they are surrounded by the bone; but when the surrounding osseous tissue is broken through, they show a very rapid growth and produce metastases.

Although, from what has been said, it is seen that the sarcomas have a greater clinical malignity than the other tumors of the connective-tissue type, still, in comparison with the carcinomas, they may almost be considered benign. This is shown, apart from the lesser tendency of the sarcoma to metastases, in the influence which the two types of tumors respectively exert on the general constitution. A condition known as the cancerous cachexia is the ordinary result of a carcinoma, even when it is confined to a single organ, while an enormous sarcoma will not ordinarily produce such a condition. This difference is in great part due to the lesser tendency of a sarcoma to ulceration, and to the fact that the degree of pain experienced from the sarcoma cannot compare with that produced by the carcinoma. This lesser tendency to ulceration may be explained by the abundant vascularization of the sarcoma, and by the slight tendency of its cells to degeneration. In still another way is the minor malignity of the sarcoma, in comparison with the carcinoma, manifest. Even those sarcomas which are shown to be very malignant in their later course by a general extension in the body, have a primary period when they may almost be regarded as benign. The carcinoma, on the other hand, from the moment it first appears and can be recognized as being such, is malignant, and shows this by the early infection of those lymphatic glands which stand in relationship to it. The sarcoma in its beginning may be a perfectly circumscribed tumor, but the carcinoma never is.

The benign period of the growth of a sarcoma is shown by its slow and circumscribed growth. In this early benign period the entire tumor is often enclosed by a connective-tissue capsule, and in those developing in bone this connective-tissue capsule may be substituted by an osseous capsule. The rapidity of the primary local growth varies in the different species of sarcoma. In many cases the growth is so rapid that we are reminded more of the extension of an inflammatory process than of the growth of a tumor. The tumor itself, in these cases of primary rapid growth, is generally a round-cell, encephaloid sarcoma, and may be very similar, even in its histological structure, to an inflammatory focus.

This primary benign period that a sarcoma passes through is of great clinical importance, and shows that the tumor should be removed as early as possible. In this removal care should be taken not only to remove all of the tumor that is apparent, but a considerable amount of the surrounding tissue as well. Even when this appears to be unaffected, it may contain, at a comparatively early period in the history of the tumor, long prolongations of tissue extending from the tumor. Any of this tissue left behind will serve as a point of departure for a returning growth. The known tendency of the sarcoma to return, after apparently complete extirpation, is only to be explained by imperfection of its removal. When a sarcoma is seated in the marrow of bone, it is impossible to say how high up the marrow is affected, and in this case disarticulation is a better operation than amputation.

The seat of the sarcoma is most often found in the skin and subcutaneous tissue. In the intermuscular and muscular connective tissue, in the fascia, and especially in the periosteum, the spindle-cell sarcoma is a very common tumor. Other varieties of the sarcoma show an especial predilection for certain tissues, as the melanosarcoma for the eye. The alveolar sarcoma is most often found in the testicle. Among the most interesting sarcomas, from a histological point of view, are those which develop in glands. These almost always include some of the glandular elements, which undergo various changes of form. In general, glandular structures show a comparative immunity from the development of sarcoma, though there are exceptions to this rule. The female breast is often attacked by sarcoma, which forms here large, round, lobulated growths, often very elastic to the touch. The tumor grows slowly, causes little or no pain, and is separated from the remainder of the gland. On section, small fissures are seen in the tumor, and often a mass of tumor-tissue will project like a polypus into one of these fissures, and be almost surrounded by it. On microscopic examination these fissures are found to be lined with epithelium, and are certainly formed by the dilated and flattened glandular ducts. The entire tumor may be enclosed in one of these fissures. Cysts formed both by degenerative processes in the tumor, and by an accumulation of secretion in gland-ducts, may be met with. The growth of these tumors is a very slow one, and is painless except when they attain a very large size. Many of them have the peculiarity of swelling up and becoming more painful during the menstrual period. Return after extirpation is not to be feared in young patients, but it may occur in patients thirty or forty years of age or older. Sarcomas also appear in the salivary glands, especially in the parotid, and here they are accompanied by a growth of the epithelium. The inner surface of the dura mater, and the substance of the brain or spinal cord, may be the seat of sarcoma. In the cord they may be multiple, one case having been seen by the writer in which four tumors, which varied in size from a small pea to a bean, were found at various places along the cord. The largest, which reached the size of a bean, was found in the cervical swelling, completely enclosed by the cord.

Concerning the etiology of sarcoma, what little there is to be said will be found in the article on Growths. It is an interesting fact that those tumors whose structure is most like very early embryonic tissue are most malignant.

W. T. Councilman.

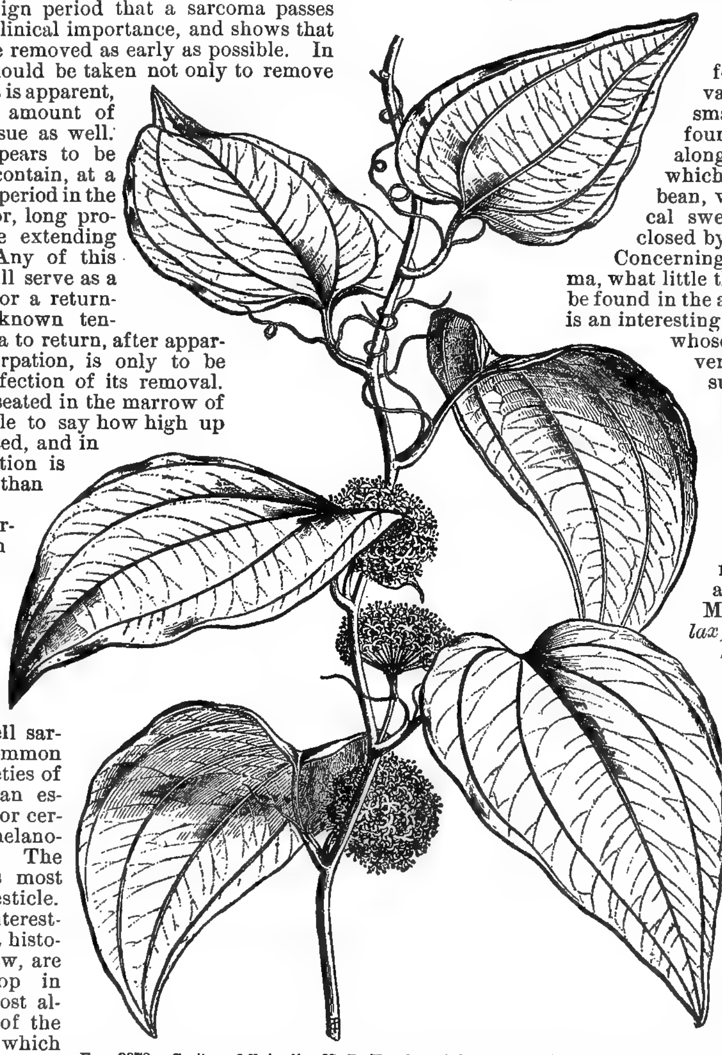

FIG. 3378.—Smilax Officinalis, H. B. K., the origin of Jamaica sarsaparilla; male plant. (Baillon.)

SARSAPARILLA, U. S. Ph. (*Sarsæ Radix*, Br. Ph.; *Radix Sarsaparillæ*, Ph. G.; *Salsepareille*, Codex Med.). The long, cylindrical roots of several Central and South American or Mexican species of *Smilax;* order, *Liliaceæ* (tribe, *Smilaceæ*). The Smilaxes are perennials, with woody, often very long and slender roots, and generally with tough, woody (rarely herbaceous), climbing or wandering stems. These are generally green and smooth, or pubescent, round, square, or several-angled, and armed with strong, flattened, recurved, sharp prickles. The leaves are alternate, generally two-ranked, petiolate, with, in most species, a long, strong tendril, arising on each side of the petiole below the middle. Blade usually oval, ovate, or heart-shaped, from three- to five-nerved, reticulate between the principal nerves; often coriaceous, and evergreen. Flowers small, greenish-white, in axillary umbels, diœcious or polygamous; perianth three- to six-parted (or more). Stamens in the male flower usually six, attached to the bases of the sepals; anthers introrse, apparently one-celled; pistil rudimentary—in the female flower, pistil three-celled, with two (or one) ovules in each cell; staminodes six, three, or variable. Fruit, a one- or two-seeded berry. The genus contains toward two hundred species of tropical or temperate plants, some of which make the most impenetrable

underbrush. Some are not spiny, a few are not climbers, and a smaller number have herbaceous, annual stems. The genus is well represented in the United States by toward a score of species, among which *S. rotundifolia* Linn., the common Greenbrier, and *S. herbacea*, the Carrion Flower, with its horribly fetid odor when in bloom, are familiar examples. The former is a very good representative in appearance and habit of the medicinal Smilaxes. Of these, it is surprising how little exact knowledge we have; specimens have been collected of most of them, but never in bloom, and the botanical details are therefore wanting, so that how much the different varieties of the drug owe to difference in species, and how much to difference in climate or cultivation, cannot in all cases be said.

1. *S. officinalis*, a large, coarse, woody climber, with a short, thickened rhizome, whence are given off numerous long, cylindrical, horizontal roots, and several or many round, erect stems, soon becoming more or less angled, and branching into quadrangular, very long, flexuose, climbing branches, armed with stout, sharp prickles. Leaves very large, or smaller on the upper portions of the plant, round, heart-shaped, ovate, or broadly lanceolate; in short, it is like a gigantic greenbrier. It is a native of New Granada, and appears to be the plant introduced into the West Indies. It probably yields "Jamaica Sarsaparilla." Female flowers and fruit not seen.

2. *S. medica* Cham and Schl., a large climber, with mostly unarmed angular branches, and frequently auriculate or lobed leaves. It grows in Mexico, and supplies the Mexican variety.

S. papyracea Poiret, with a many-angled stem; flowers unknown; of Guiana and Brazil; may be the source of Para Sarsaparilla, etc. Of several other imperfectly known species there is a suspicion of probable connection with the drug, but no certain knowledge.

Sarsaparilla was first carried to Europe about 1536–45, and first or early employed as a cure for the same disease with which it has been since most generally associated, and for which another smilax, "China," had previously been used. The use in numerous other slow diseases, especially in eruptions and as a "blood-purifier" in general, followed, and has continued extensive until the present time. Although now it has been nearly discarded as a serious medicine by physicians, it is still a much-prized popular remedy.

Collection.—This has been observed several times, and consists in selecting clumps where numerous stems indicate plenty of roots, clearing away the dirt and other roots around them, and carefully digging up the long, whip-like sarsaparilla; the crowns and remnants are then covered with dirt and leaves, and left to sprout again, or in some countries collected with the roots. The collected roots are simply dried and packed in more or less characteristic bundles.

Description.—Sarsaparilla comes in long, simple, or sometimes forked, longitudinally wrinkled (when dry), flexible, slender, rope-like roots, in some varieties thicker in the middle than at either end, often one or two metres in length, and from two to five or more centimetres in diameter; surface light or dark brown, with scattered fine roots, and sometimes short, velvety hairs. The rhizome—a dark, irregular, woody "chump"—is present in some varieties. The roots vary considerably in their plumpness, owing to a very variable amount of starch in their tissues, which fact has given rise to their division into two general groups: *a*, Starchy, or mealy—Honduras, Guatemala, Brazilian, Para, etc.; *b*, non-starchy—Jamaica, Mexican, Guayaquil, etc. There is no important difference in their medicinal qualities, but the non-mealy varieties are darker and rather stronger-tasting. These varieties are more easily told sometimes by their mode of packing than by their individual appearance.

Honduras Sarsaparilla is pretty plump and smooth, with more or less "beard." Near the middle the roots contain a thick zone of white, starch-laden tissue. They are packed in hanks seventy or eighty centimetres long, wound with a flexible root, and bound in bales with hide. *Guatemala Sarsaparilla* is yellowish, with a brittle bark. *Brazilian* comes in very large, long, closely wound bundles, cut smooth at either end. "Jamaica Sarsaparilla" (the most esteemed in England, and from Central America, instead of Jamaica), is in short bundles, half a metre or so long, rather carelessly done up, wound like the others by a long, flexible root of the same; it is a slender, deeply furrowed, dark root, brown within as well as without. *Mexican* is pale, not made into bundles, and often contains also the chumps and bases of stems. *Guayaquil* comes loose in large bales. It has a large, coarse-looking root, accompanied also by the rhizomes and some stem-bases.*

The histology of Smilax roots has been studied with more care and detail than their unimportance deserves. (See Berg's "Atlas zur Pharm. Waarenkunde.")

The (endogenous) woody portion is collected in a central core, and surrounded with a false bark of thin-walled, parenchymatous, starch-laden cells, of varying, often considerable, thickness. The woody column consists of a parenchymatous centre of thin-walled cells, surrounded by a progressively increasing number of scattered woody and vascular bundles, compacted into a hard, porous wood near the circumference of the column.

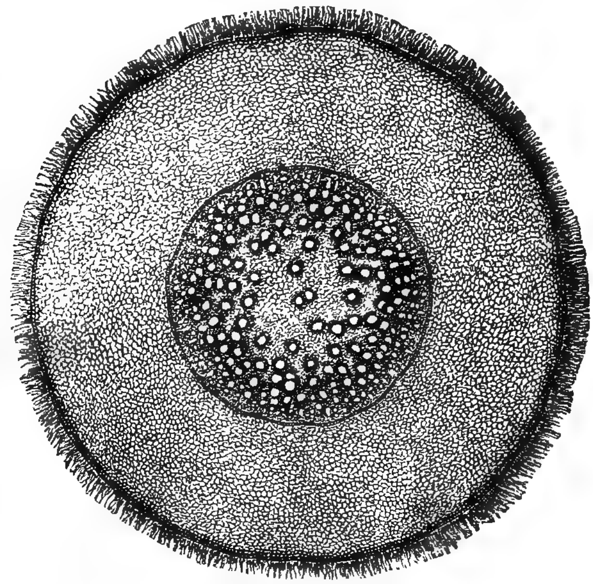

Fig. 3379.—Root of Smilax Officinalis, Enlarged Section. (Baillon.)

Composition.—Most earnest attempts have been made to find a tangible and useful active principle in Sarsaparilla, with only partial success. *Starch* in most varieties is abundant, but unimportant. *Essential oil* in minute quantity, a little *resin*, "*extractive*," etc., may have some value, but the most characteristic substance is *parillin*, of which about two per cent. may be obtained. It crystallizes in white scales or needles, permanent in the air, neutral, odorless, at first tasteless, but afterward bitter and acrid; but little soluble in either cold water or alcohol, freely so in hot. It is more soluble than in either alone in a mixture of alcohol and water. Parillin is a glucoside, yielding *parigenin* and *sugar* if treated by dilute mineral acids (Flückiger). Parillin is, as yet, of doubtful composition, but is nearly related to *saponin*.

Action and Use.—This paragraph will seem short compared with the preceding descriptions. Parillin, in doses of half a gram or so, produces nausea, vomiting, and retardation of the pulse; in larger doses, constriction in the throat, weakness, sweating. It has been tried to a slight extent in syphilis, without marked results (Husemann). Sarsaparilla itself, in large doses, only produces

* Hanbury and Flückiger.

gastric disturbance, so from the physiological action of this remedy little therapeutic value can be predicated, and it probably has not much. Yet, on the other hand, not only this, but other products of Smilax (China, Eastern Sarsaparilla, etc.) are used the world over for syphilitic and scrofulous diseases, in the United States perhaps less seriously than elsewhere. It does seem possible that Sarsaparilla in fair doses is beneficial in some cases of dyspepsia or mal-assimilation arising from winter diet or improper food, and hence its popularity in "Spring medicines;" but the bitters in general, and some laxatives (Gentian, Dandelion, Frangula, etc.), are equally or more efficacious. Its use in "scrofula" is diminishing. In syphilis it is still a good deal prescribed, especially in England, India, etc.

ADMINISTRATION.—Smilax is never given in substance, but the theoretical dose may be stated as from four to eight grams (ʒ j.–ʒ ij.). The best preparations are the Fluid Extract (*Extractum Sarsaparillæ Fluidum*, U. S. Ph.), strength, $\frac{1}{1}$; the Compound Fluid Extract (*Ex. Sarsaparillæ Comp. Fluid.*, U. S. Ph.): Sarsa., 75; Glycyrrhiza, 12; Sassafras, 10; Mezereum, 3; Glycerin, 10; alcohol and water enough to make 100; strength, $\frac{1}{1}$; the Compound Decoction (*Decoctum Sarsaparillæ Comp.*, U. S. Ph.): Sarsa., 10; Sassafras, 2; Guaiacum, 2; Glycyrrhiza, 2; Mezereum, 1; water enough to make 100; strength, $\frac{1}{10}$, and the Syrup, more used than the others, because used as a vehicle. It is composed as follows:

Sarsaparilla	150	parts.
Guaiacum	20	"
Pale rose	12	"
Glycyrrhiza	12	"
Senna	12	"
Sassafras	6	"
Anise	6	"
Gaultheria	6	"
Sugar	600	"

Water and diluted alcohol enough to make 1,000 parts. The Infusion and Fluid Extract are the best forms where full doses are to be given.

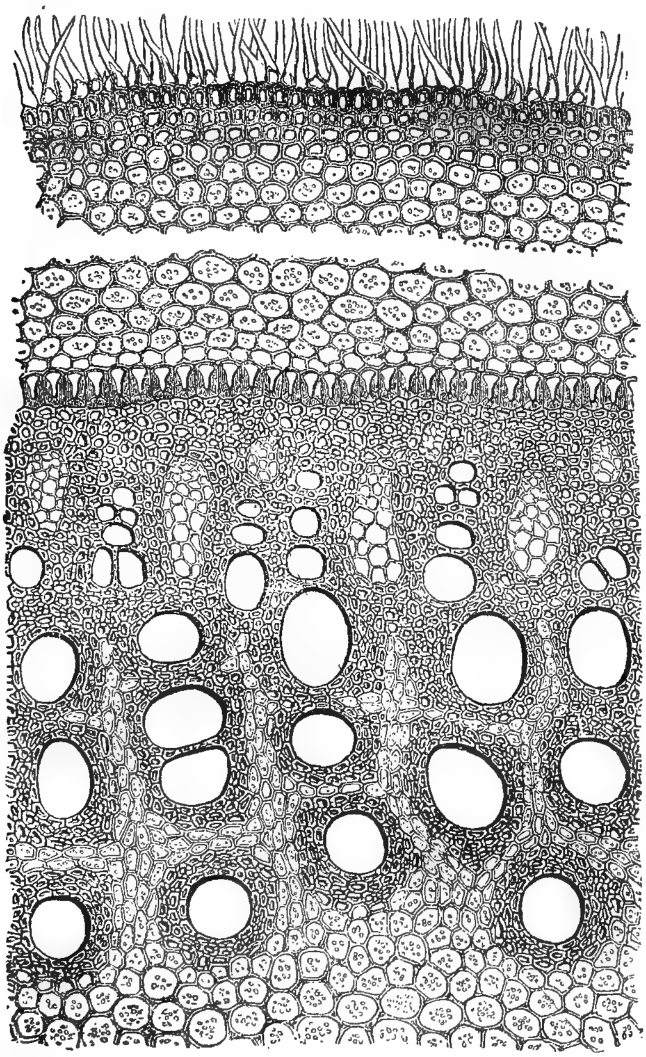

FIG. 3380.—Magnified Section of One-half Diameter of Root of Smilax Officinalis. (Baillon.)

ALLIED PLANTS.—The suborder *Smilaceæ* forms a rather distinct division of the great modern group collected under the name *Liliaceæ;* it includes but little more than the great genus *Smilax* described above. China Root, from *Smilax China* Linn., in large, Jalap-like tubers, is used in the East for the same purposes as sarsaparilla. For the order, see SQUILL.

ALLIED DRUGS.—In the treatment of syphilis and scrofula, and many of the conditions for which Sarsaparilla was once highly esteemed, Mercury, Iron, and Iodine have long since taken the principal place. There is, however, a long list of dubious remedies from the vegetable kingdom, which have a reputation, mostly local, as "alteratives," or anti-scrofulous and anti-syphilitic substances; few of them are more than household drugs. China, just mentioned, Hemidesinus or Indian Sarsaparilla, our False Sarsaparilla, are among them. Guaiacum, Mezereum, etc., are more generally used; Colchicum, Stillingia, Sanguinaria, Chelidonium, Dulcamara, and Arsenic also help to fill up this heterogeneous collection. *W. P. Bolles.*

SARSAPARILLA, FALSE, *Aralia nudicaulis* Linn., order *Araliaceæ.* This little plant, generally known among country-folks and herb-gatherers as "sarsaparilla," has no botanical relation whatever to the preceding drug; in taste and in the shape and size of the roots there is a little similarity. It consists of a long, slender, perennial root, about as large as a pipe-stem, and two or three metres in length, with a light-brown surface and soft, flexible texture. It has a rather pleasant, aromatic odor, and an aromatic, somewhat sharp taste. The stems, which arise at intervals of from twenty to fifty centimetres, are only one or two centimetres long, barely emerging from the ground, and give rise, each, to one twice ternately or quinately compound leaf, and one three-branched scape supporting three globular umbels of small greenish-white flowers. This *Aralia* is common in moist places over most of the United States, and is in some popular demand for the same complaints that sarsaparilla is reputed to benefit. Dose indefinite. Composition not known.

ALLIED PLANTS.—The genus contains thirty species, mostly Asiatic, of herbs, or rather shrubs, of mild, indefinite medical properties. *A. racemosa* Linn., American Spikenard, and *A. quinquefolia* D. & P., American Ginseng, are other native species employed in popular medicine. The Ivy (*Hedera Helix*) also belongs in the family.

ALLIED DRUGS.—See SARSAPARILLA.

W. P. Bolles.

SASSAFRAS, U. S. Ph.; Codex Med. (*Sassafras Radix*, Br. Ph.; *Lignum Sassafras*, Ph. G.). *Sassafras officinale* Nees, one of the very few plants of the Laurel family growing wild in this country, is a medium- or

good-sized tree, or, near the northern boundary, a shrub or small tree, with irregular, spreading, brittle branches, covered like the trunk with rough, furrowed bark, gray without, fawn-colored or pinkish when freshly cut, within. Wood light-colored, with darker heart. Twigs and smaller branches bright green, glossy; pith large, very mucilaginous. Leaves bright-green, smooth, oval, pointed at each end or blunt at the apex, entire, or else, especially those coming later in the season, deeply three-lobed; between these shapes are various intermediate ones, lobed on one side, and not on the other, or merely auriculate on one or both sides. Both kinds of leaves are usually seen on the same tree. Flowers vernal, appearing with the leaves, in small racemes; small, regular, diœcious, yellow. Perianth six-parted. Stamens nine; the three inner ones glandular at the base; anthers four-celled, each opening by means of a little valve. Pistil one, one-celled, with one pendant ovule. In the staminate flowers the pistil is rudimentary; in the pistillate ones there are six sterile stamens. Fruit a blue berry, on a reddish, cup-shaped receptacle. All parts of the tree are fragrant, especially the bark of the root; the growing parts contain also considerable mucilage.

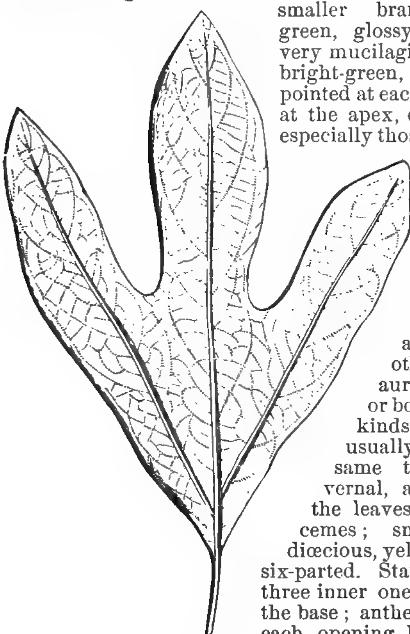

FIG. 3381.—One of the Three-lobed Leaves of Sassafras. (Baillon.)

Sassafras has a wide range over the United States, extending slightly into parts of Canada, etc. In many regions it is very abundant, New Jersey, Pennsylvania, Maryland, and Virginia supplying large quantities both of the bark and oil. It has been valued since the settlement of the country, and is said to have been used by the aborigines even before. Although its reputation as a medicine is a thing of the past, as an agreeable flavor and cheap perfume it is in steady demand. There is very little call for the whole root in this country, excepting what is used on the spot in the manufacture of the oil; but considerable is exported to Great Britain and the Continent, the Bark of the Root (technically called Sassafras, U. S. Ph.), being preferred. The officinal description is as follows: "In irregular fragments, deprived of the gray, corky layer; bright rust-brown, soft, fragile, with a short, corky fracture; strongly fragrant, sweetish, aromatic, and somewhat astringent." Sassafras Pith (*Sassafras Medulla*) is "in slender cylindrical pieces, often curved or coiled, light, spongy, white, inodorous, insipid. Macerated in water it forms a mucilaginous liquid, which is not precipitated on the addition of alcohol."

COMPOSITION.—Of the wood and bark: The most important constituent here is the *essential oil* (*Oleum Sassafras*, U. S. Ph.), of which the wood contains perhaps one per cent., the bark of the root from two to four per cent. It is a heavy (sp. gr. 1.087+), white, or by age yellow, and then reddish-brown, very fragrant liquid, of an agreeable aromatic taste and a neutral reaction. Soluble freely in alcohol. By the action of cold, or upon standing, it can be separated into *Safrol*, or sassafras camphor, which comprises its principal portion, and *safrene*, a hydrocarbon; both have the same odor. Both bark and wood contain also a little *tannin*, and the bark contains a *red coloring matter*, perhaps derived from the tannin.

Sassafras Pith contains a peculiar non-adhesive *mucilage*.

ACTION AND USE.—Sassafras, like Cinnamon, to which it is related, is an aromatic tonic and carminative, with little or no peculiarity of action to distinguish it from others of its class. It is said to be a stimulating diaphoretic, but probably is not more so than most aromatics, or essential oils, when given in hot "teas." It is, however, of an agreeable flavor, and for this quality it is freely used as an adjuvant in medicine, and as a flavor for confections, soaps, and other household luxuries. The mucilage of the Pith (*Mucilago Sassafras Medullæ*, U. S. Ph., $\frac{2}{100}$) is used rarely as an eye-wash, or as a gargle or demulcent drink for pharyngitis.

ADMINISTRATION.—Oil of Sassafras may be given in doses of from five to ten drops or more on sugar, or in emulsion with mucilage, or otherwise, for the same purposes as oil of Cinnamon or Checker-berry, or an infusion may be made of the bark. Sassafras Bark is an ingredient of the Compound Extract, the Compound Decoction, and the Compound Syrup of Sarsaparilla.

ALLIED PLANTS, ETC.—See CINNAMON.

W. P. Bolles.

SASSY BARK, *Mancona Bark.* The bark of *Erythrophlæum quinense* Don.; order, *Leguminosæ* (*Cæsalpinieæ*), a good-sized, acacia-like tree, growing in tropical Africa, and employed by the tribes of the west side like Calabar Beans, as an ordeal. It was made known in Europe and America about forty years ago, and was revived as a medicine about ten years since. It is a ponderous bark, heavier than water, of a dull red color, a fissured external surface, and a short fracture. Odor slight, taste astringent. The active principle of Sassy Bark is *Erythrophlæine*, a crystalline alkaloid, first obtained by Gallois and Hardy. It is an active heart-poison of the digitalis kind, producing slowing of the pulse, increase of blood-pressure, and in experiments upon animals death, with the heart in systolic contraction. The powdered drug is a powerful sternutatory. But little use has been found for this potent medicine. It is said to be employed at home in dysentery, etc., with benefit, as well as in intermittent and other fevers. In full doses it is nauseating and emetic, as well as somewhat narcotic.

ALLIED PLANTS, ETC.—See SENNA. *W. P. Bolles.*

SAUNDERS, RED (*Santalum Rubrum*, U. S. Ph.; *Pterocarpi Lignum*, Br. Ph.; *Santal Rouge*, Codex Med.). The heart-wood of *Pterocarpus santalinus* Linn., order *Leguminosæ* (*Dalbergieæ*). A small tree with red wood, alternate trifoliate leaves, small yellow, papillionaceous flowers on axillary racemes, diadelphous stamens, and a flat, orbicular, wing-margined, one- or two-seeded, stalked, indehiscent fruit. It is a native of the Madras Presidency, but not common, and is now being cultivated.

Red Saunders is imported in billets three or four feet in length, and from two to eight or nine inches in diameter, the bark and sapwood being removed. It is of a bright blood-red color within, but darker upon the surface, becoming sometimes nearly black with age and exposure. For pharmaceutical use it is usually cut into chips or powder. There is a slight astringent taste, but little or no odor. Alcohol and ether extract its constituents, but not so with water, which it scarcely colors. The important principle is *Santalin*, or *Santalic acid*, discovered by Pelletier. It crystallizes in minute red prisms, which are soluble as above, and in alkaline solutions and a few essential oils. Besides this, a number of less important or ill-defined substances are described.

Saunders is essentially a dye-stuff. In medicine it has no employment, excepting as a harmless coloring agent. The Compound Tincture of Lavender contains eight parts in the thousand.

ALLIED PLANTS.—KINO; see also SENNA.

ALLIED DRUGS.—Saffron, Annato, Cochineal, etc.; also the red coloring matter of Kino, Red Cinchona, Krameria, etc. *W. P. Bolles.*

SAVINE (*Sabina*, U. S. Ph.; *Sabinæ Cacumina*, Br. Ph.; *Summitatis Sabinæ*, Ph. G.; *Sabine*, Codex Med.). The leaves and young twigs of the European *Juniperus Sabina* Linn., order *Coniferæ*. This is a compact, horizontally spreading, evergreen shrub or small tree, resembling our common juniper on a small scale, and bearing similar berries. It is widely distributed through the north temperate zone of the Old World, and is also met within the Northern United States (in the Great Lake region) and in Canada. The medical supply comes from Europe, in "short, thin, sub-quadrangular branchlets, leaves in four rows, opposite, scale-like, ovate lanceolate, more or less acute, appressed; imbricated, on the back with a shallow groove containing an oblong or roundish gland; odor peculiar, terebinthinate; taste nauseous and bitter."

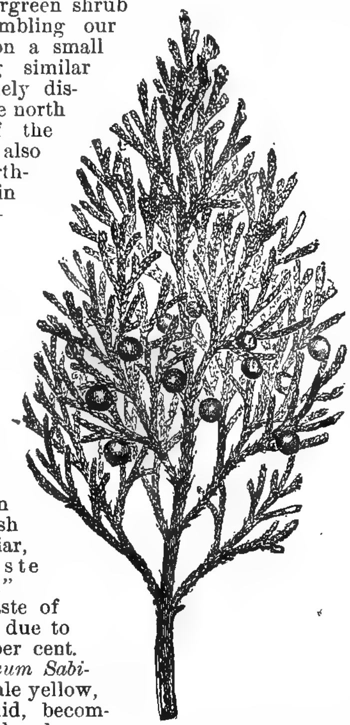

Fig. 3382.—Savine, Fertile Branch. (Baillon.)

The odor and taste of Savine are mostly due to from one to two per cent. of *essential oil* (*Oleum Sabinæ*, U. S. Ph.), a pale yellow, terebinthinous liquid, becoming thicker and darker by age, colorless if redistilled, of a specific gravity of about 0.910. It has the odor of Savine, a sharp, bitter, camphoraceous taste, and is more rubefacient and irritating to the skin than others of its class. *Tannin* and *resin* are less important constituents of Savine.

ACTION AND USE.—Savine and its oil are essentially like, but more intense than, oil of turpentine in physiological and therapeutical properties; irritating to the skin and mucous membranes, to the urinary apparatus by which they are eliminated, and to the uterus, which they may cause to abort. Besides these effects, convulsions and coma may follow. Vomiting, diarrhœa, gastro-intestinal inflammation, strangury, with or without convulsions or unconsciousness, these are the usual symptoms of Savine-poisoning; abortion may or may not take place. This potent drug is not much employed. It has been given as an emmenagogue, also as a hæmostatic, for leucorrhœa and other purposes mostly connected with the uterus. It is not infrequently used with criminal intent to produce abortion, usually without success, unless it nearly or quite kills the mother also; externally it is the basis of some moderately useful stimulating ointments, liniments, and "hair-restorers."

In this country the Oil of Juniper, which is milder, is perhaps generally substituted for Oil of Savine.

The dose of Savine (leaves) is about half a gram (0.5 Gm. = gr. viij.); of the oil, from one to four or five drops. A Fluid Extract of the former (*Ex. Sabinæ Fluidum*, U. S. Ph.) is an eligible preparation and the basis of the Cerate (*Ceratum Sabinæ*, U. S. Ph., strength about $\frac{25}{100}$ Savine).

ALLIED PLANTS.—See TURPENTINE; also JUNIPER.

ALLIED DRUGS.—TANSY, RUE, TURPENTINE, CAMPHOR, CAJEPUT, etc. *W. P. Bolles.*

SAVORY, SUMMER (Sarriette, Codex Med.). The herb of *Satureia hortensis* Linn., order *Labiatæ*, a well-known European mint, now cultivated everywhere as a flavoring herb for soups and sauces. It has no properties not common to other mints and aromatics in general, and is only employed for its agreeable odor and taste.

ALLIED PLANTS, ETC.—Hyssop, Thyme, Patchouly, Lavender, etc. See PEPPERMINT. *W. P. Bolles.*

SCABIES (Latin, *scabies*, an itching eruption, from *scabo*, I scratch). Synonyms: The Itch; German, *Krätze*; French, *Gale*. Scabies is a contagious disease of the skin, wholly local in character, due to the presence in, and upon, the skin of an animal parasite, the *acarus* or *sarcoptes scabiei* (see vol. i., p. 34). The eruption present may vary from the smallest amount imaginable, a few papules, up to the most severe development of inflammatory lesions, even such as to render the patient helpless; the subjective sensations may vary from a slight pruritus, which is described as not unpleasant when relieved by scratching, up to an itching which is almost unendurable, causing restless nights and distressing days.

The most common sites for the lesions of scabies are the hands, especially about the wrists, in the soft skin between the fingers, and on the sides of the hands. But in many cases the eruption is entirely absent from this locality and is well marked elsewhere. In males the penis seldom escapes, and in females the region of the nipples is very apt to be affected; the anterior fold of the axilla is a very common seat of the lesions, and the elbows and extensor surface of the forearms are sometimes most severely affected. In those who sit a great deal the buttocks often present an abundant eruption. In infants and children the softer parts of the feet and ankles generally exhibit lesions. It may be said that the head is never affected by scabies.

The eruption of scabies exhibits the greatest variety of lesions, from the smallest papules and vesicles to large pustules, often ecthymatous in character, and in weakly children pustular bullæ may form on the hands. The bulk of the lesions is papular, although small vesicles can generally be seen on tender portions of the skin during some period of the disease. Mingled with these primary lesions there are generally found the results of scratching, abraded surfaces, and those covered with crusts.

The only single pathognomonic sign of scabies is the *cuniculus*, furrow, or burrow (German, *Milbengang*; French, *Sillon*), which is caused by the penetration of the female beneath the epidermal layer of the skin in the search of a place to lay her eggs; the male seldom, if ever, goes beneath the skin. This cuniculus consists of a minute dark-colored line, generally somewhat beaded in appearance and curved, appearing much as if a bit of dark sewing-silk had been run beneath the surface, rarely as long as a fourth of an inch, more often half that length; this may generally be seen to terminate at one end in an inflamed papule or vesicle, or sometimes to run over a pustule. The female insect will be found at that end of the furrow, and the dark line is her track, which is found to be filled with eggs in various stages of development, and, among them, black particles of fæces. If the skin is washed these dark lines, instead of being removed, become more apparent; but in recent cases, or in individuals who are very cleanly or have undergone treatment, it is often impossible to discover any of these cuniculi, although the disease may still exist, and, if left alone, will increase and may be communicated to others.

Scabies is not a very frequent disease in this country, forming only about 1.5 per cent. of a large number of skin cases analyzed. In other countries it is more common, and in Glasgow it formed twenty-five per cent. of ten thousand cases analyzed by McCall Anderson.

DIAGNOSIS.—Considerable care is often required to diagnose a mild or unusual case of scabies, and cases sometimes go unrecognized for some time. The disease most commonly confounded with it is eczema, which may present almost identical appearances, except that there are no cuniculi; when these latter are positively

found the diagnosis is certain. The location and distribution of the eruption, the history of contagion, and the multiform character of the lesions are generally sufficient to establish the diagnosis. Scabies may also be confounded with lichen, pityriasis, prurigo, pruritus, and urticaria papulosa.

ETIOLOGY.—There is but one cause of scabies, the presence of the parasite, acarus or sarcoptes scabiei (see article Acari in vol. i. of this HANDBOOK), whose removal or destruction is followed by the cessation of the disease. It often occurs, however, that the treatment employed may occasion an amount of artificial eruption or dermatitis which may mask the true affection, and may even remain after the real cause of the disease has been destroyed; this second eruption may require a very different treatment, of a soothing character.

PATHOLOGY.—The only pathological lesions, aside from the presence of the cuniculus, which is a channel beneath the epidermis and just above the papillæ, filled with the female acarus, its eggs, and fæces, are those connected with inflammation of the skin (see article Dermatitis). The lesions are simply inflammatory masses of greater or less size, caused either by the direct irritation of the burrowing insect, or by the scratching or other measures employed for the relief of the itching, or both. When the local irritation is removed the eruption ceases; if the acari could all be removed mechanically, picked out, there would be no eruption. In patients who are paralyzed on one side, or who have been unable to scratch, there is very little eruption on the portions of the skin which are out of reach.

TREATMENT. — The treatment of scabies is purely local, and consists in such measures as destroy the life of the parasitic insects and their eggs. The patient first takes a warm bath, using plenty of strong soap, rather alkaline in character, such as the sapo viridis or the common laundry soap, rubbing the affected parts so as to break the furrows as much as possible. After drying, the affected parts, or even much of the body, should be well rubbed with an ointment of which sulphur is a chief ingredient. The ordinary sulphur ointment diluted once, with the addition of a drachm of liquid storax to the ounce, answers as well as anything. After thorough friction with this for at least half an hour, the patient puts on underclothes, which are to remain on night and day until the end of treatment. The ointment should be freshly rubbed in twice daily for several days, and a bath is to be taken on the third day, the ointment being again rubbed in and a fresh suit of underclothes put on. After three days more of treatment another bath may be taken, and it is then to be expected that the cure is complete. But frequently some of the cuniculi will be found to have escaped being broken, or new infection may come from the clothing or elsewhere, and in such case the treatment must be repeated. Sometimes an artificial eruption is excited by the treatment, when soothing remedies are required. The clothing should always be treated; the underclothes should be boiled a long time and very thoroughly ironed; the outer garments may be baked or very thoroughly ironed on the wrong side. Patients should be more or less isolated, although when they are under treatment the chances of communicating the disease are very small.

PROGNOSIS.—The prognosis is, of course, favorable; there can never be the slightest harm in curing even the most inveterate or severe cases of scabies. In the hospitals abroad it is claimed that a cure is effected in a few hours, but it is questionable if, in the large majority of cases, the relief is more than temporary, a portion only of the parasites being killed. Practically, cases require treatment for a number of days, or even weeks, to make the cure certain; when the skin is delicate the active parasitic treatment may have to be interrupted, owing to the dermatitis excited, and occasionally it will be found difficult to use remedies strong enough to effect a cure.

L. Duncan Bulkley.

SCABIOUS (*Scabieuse*, Codex Med.); *Morsus Diaboli, Succisa pratensis* Mönch, order, *Dipsaceæ* (*Scabiosa succisa* Linn.). A European herb, whose roots, leaves, and heads were formerly in vogue as a remedy for leucorrhœa, diabetes, throat affections, and skin diseases. It is now obsolete.

ALLIED PLANTS, ETC. — *Dipsacus Fullonum* Linn., in the same family, is the teazle used by woollen weavers. "Sweet Scabious" (*Erigeron*) is an entirely different plant. *W. P. B.*

SCAMMONY (*Scammonium*, U. S. Ph., Br. Ph.; *Scammonée d'Alep*, Codex Med.; also *Scammoniæ Radix*, Br. Ph.). The impure resin obtained from the root of *Convolvulus Scammonia*, order *Convolvulaceæ*. This is a perennial with a long, thick, cylindrical, several-headed, but otherwise usually simple, milky-juiced root, and numerous hollow, herbaceous, slender, smooth, twining stems, two or three metres long. The root, which is an article of English trade, is up to a metre in length, and a decimetre in diameter at the crown, light brownish-yellow without, white within, fleshy, and resinous. The leaves are infrequent, alternate, long-petioled, triangular, halberd- or arrow-shaped, pointed at the apex, with one or two obtuse dentations near the cordate base. Flowers five or six centimetres across, pale yellow, solitary or in cymes of three, on long two-bracted peduncles. Calyx five-parted; corolla conduplicate in the bud, broadly funnel-shaped when open, with an indistinctly five-parted border. Stamens five, attached to the corolla tube, pistil two-celled, four-seeded.

FIG. 3383.—Scammony-plant in Blossom. (Baillon.)

This pretty plant is a native of the Levant—Greece, Asia Minor, Syria, etc. It is also cultivated in botanic gardens. The resin is collected by cutting off the root

at the crown, and either scraping off the exudation as it appears or putting a shell or some receptacle at the lower side to receive it as it runs down. It is then dried at once, constituting a very high grade of the drug, or more usually the separate collections are laid aside until enough is accumulated to make a "cake," when it is all moistened and kneaded together. In this way the bubbles and sour odor are developed, and what is known as "Virgin Scammony" is produced.

Scammony is in "irregular, angular pieces, or circular cakes, greenish-gray or blackish, internally porous, and of a resinous lustre, breaking with an angular fracture; odor peculiar, somewhat cheese-like; taste slightly acrid; powder gray or greenish-gray." The porous, bubbly texture, and the sour, cheesy smell are results of fermentation during the process of drying. It is soluble to the extent of three-fourths in ether. The costliness and opaque color of Scammony render it especially liable to adulteration. Lime, flour, ashes, gum, etc., are among the common admixtures. The proportion of resin is the best test of purity. This *resin* (*Resina Scammonii*, U. S. Ph.) is obtained by digesting the drug with alcohol and evaporating the tincture so obtained, or by treating the root in the same way. It is a brown, translucent, brittle resin, with a sweet, fragrant odor if obtained from the root; but, as usually seen, from crude Scammony, it is more greenish and dirty in color, and has the odor of Scammony itself. The action and value of the two products are about the same.

COMPOSITION.—The peculiar resin of Scammony, unfortunately called *jalapin*, first obtained in a state of purity by Johnston, in 1840, differs from the *convolvulin* of jalap by its solubility in ether. When purified it is a colorless, translucent, brittle, non-crystalline resin, tasteless and odorless, of nearly neutral reaction, and freely soluble in ether. It is a glucoside, and resolvable into *jalapinolic acid*, a crystalline substance, and sugar. Good Scammony contains eighty or ninety per cent. of this resin.

ACTION AND USE.—Scammony and its resin are to be counted among the very active drastics, excelled only by croton-oil and elaterium. Their action is similar to that of jalap, but considerably more intense. They are used as derivatives and hydragogue cathartics in cases of cardiac and renal troubles associated with dropsy. Scammony resembles the action of jalap, but is more intense. Aromatics and carminatives are appropriate adjuvants. Dose, of good Scammony, half a gramme or so; of the *Resin*, three or four decigrammes. The compound Extract of Colocynth contains fourteen per cent. of Resin of Scammony.

ALLIED PLANTS, ETC.—See JALAP. *W. P. Bolles.*

SCAPULA: DISEASES AND INJURIES OF THE CORACOID PROCESS. The coracoid process (Syn.: Processus Cornicularis, Hawk-bill Process) is usually described as a short, thick, curved process of bone, rather more than one inch in length, which arises by a broad base, and projects beneath the outer end of the clavicle from the anterior part of the upper margin of the scapula. It is first directed upward and inward, then, becoming smaller, it changes its direction and passes forward and outward. The horizontal portion is irregular and flattened from above downward, the under surface is smooth, while the internal and external borders are roughened for the attachment of ligaments and muscles.

The ligaments are—the origins and insertions corresponding to the situations named—the coraco-clavicular, coraco-acromial, and coraco-humeral. The muscular attachments are the short head of the biceps, and the tendons of the coraco-brachialis and pectoralis minor muscles. In position the coracoid process is almost unique, being uncommonly well protected by the circumjacent bony and muscular structures. The clavicle is arched above, the head of the humerus protects it from external injuries, and the deltoid and pectoral muscles complete the defence with a buffer-like elasticity, shielding it from all assaults directed from either above or below. The development of this process takes place from two centres of ossification, one in the body and the other near its base. It remains as an epiphysis until near the twenty-fifth year, a portion at birth being cartilaginous. Allen ("Human Anatomy," sec. 11, p. 171), says: "This process is homologous with the coracoid bone of batrachian reptiles and birds; as seen in these animals, the coracoid bone extends between the sternum and scapula very much after the manner of the clavicle in the human subject." In persons of moderate muscular and adipose development this process can be felt just beneath the mesial portion of the outer third of the clavicle, a short distance to the inner aspect of the head of the humerus. The hand should grasp the shoulder, the fingers at the same time steadying and pushing the scapula forward against the back of the chest; it can then, ordinarily, be recognized, by the thumb being pressed in front, as a bulbous protuberance about the size of a large bean. The arm during the manipulations should be extended and rotated outward, which, by producing traction upon the accessory ligament, brings the process forward and facilitates its detection. There is one fact which deserves to be specially mentioned because of its importance in regard to diagnosis. In the normal subject, where no disease nor injury is suspected, the coracoid will frequently be found intolerant of rude manipulation or pressure; therefore, it should be impressed upon the observer, when making examinations in this region, that a precipitate diagnosis should not be made from the mere presence of pain uncorroborated by other morbid indications.

DISEASES.—The literature of this class of affections is very meagre. Nothing seems to have been recorded that would demand any special therapeutic measures, beyond what is usually comprehended by ordinary established rules, and such as are applicable to bone disease situated in analogous structures elsewhere. It may be worthy of mention here—rather as a matter of curiosity—that the coracoid process is sometimes thought to become the seat of reflex neuralgic manifestations, due to some indefinite disturbances in the abdominal viscera. Pain felt in the right process has been attributed to vague hepatic derangement, while that of the left side is supposed to be connected with morbid conditions operating in the spleen. How far these are to be credited as demonstrations of disorder in these organs cannot at this time be determined; but it would be wise to regard these relations as extremely conjectural, and as such quite insufficient to warrant much serious consideration.

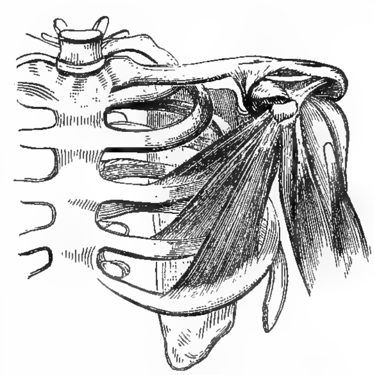

FIG. 3384.—Fracture of the Coracoid Process, showing action of muscles in its displacement.

Periosteitis, simple and tubercular osteitis, caries, and syphilitic necrosis have occasionally been observed in this process. It may be also said of these that the principles governing the management of such common forms of disease will be found the same here as elsewhere. It will, therefore, be amply sufficient for all purposes to limit our observations here to osteitis alone, this being in the common run of cases the form of disease most likely to be met with.

"Osteitis of this process occurs with greatest frequency in the period of adolescence, before the epiphyses have consolidated, and is liable to be confounded with scapulalgia, osteitis of the head of the humerus, or even cervical Pott's disease. The diagnosis may be made by

the location of the pain on pressure, and by the presence of tumefaction, or of an abscess. The latter is found usually in the subclavicular region rather than in the scapulo-humeral, or on the internal aspect of the arm, the pus following the sheath of the coraco-brachialis muscle, or the short head of the biceps.

"*Treatment.*—This consists of resection of the process by means of a T-shaped incision. In case of tubercular osteitis union by first intention cannot be hoped for, and it will be necessary to provide for free drainage" (Poncet, *Lyons Bull. Gén. de Thérapeutique*).

FRACTURES.—Injuries of this class involving the coracoid process have always been considered as remarkably rare, the ordinary surgical authorities and text-books enumerating not above a dozen examples, which are generally accepted as constituting the entire list of authentic cases. These statistics are, however, misleading, and sufficient data are not wanting, as will be shown in the tables below, to prove that the lesion is much more common than is usually believed. Writers have seemed to be possessed with the idea that this process is so well protected that fracture is wellnigh impossible without the infliction at the same time of such an extensive injury to the surrounding structures as to overshadow the coracoid trouble. This *à priori* reasoning has in time become dogmatic assertion. Experience, however, has shown that this process is not disproportionally exempt from simple fractures. The rarity of fracture of the coracoid process has been greatly exaggerated in the past, and there can be no doubt that a careful investigation, at any time during the past century, would have shown that very many anatomical collections contained specimens of this injury. The result of such a study would have been to prevent the emphatic and misleading language of Lizars, which is as follows: "The coracoid is said to be broken off, but this I question very much; it must be along with the glenoid cavity, or there must be a fracture of the neck of the scapula." No less pronounced are the remarks of the eminent Malgaigne. "This fracture is excessively rare, and does not occur except in company with other serious injuries." Holmes, Erichsen, South, and Bryant bear similar testimony, regarding it either as highly improbable or exceedingly rare, unless accompanied by marked complications, rendering it a very serious accident.

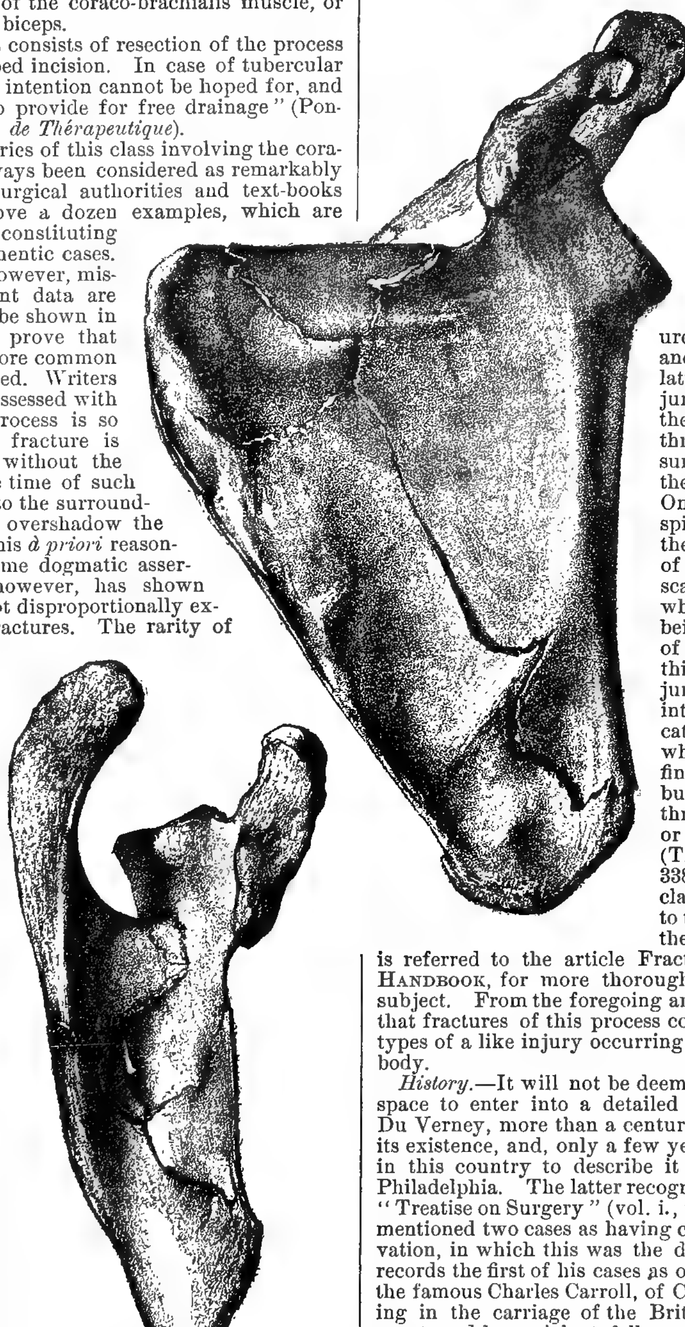

FIG. 3385.—Green-stick Fracture of Coracoid Process, with Multiple Fracture of Scapula.

Varieties.—There are three principal forms of this fracture that have been observed. The first of these, which is the most frequent of any, may be defined to embrace all fractures limited to the process proper in which the line of fracture is simple and complete. The second variety is denominated partial green-stick, or incomplete, fracture, an example of which is shown in Fig. 3385, taken from a case the dissection of which was reported by Bennett, of Dublin, to the Academy of Medicine of Ireland. This may be pronounced the most unique of specimens, and probably is the only case of the kind ever verified by an autopsy. An examination of the coracoid shows two fractures, one at the apex and another at the base; the latter break runs from the junction of the process with the glenoid cavity, on through the entire concave surface which is related to the subscapularis muscle. On looking at the supraspinous fossa (Fig. 3385), there is no trace whatever of the fracture visible. The scapula came from a man who died a few hours after being crushed by a quantity of falling masonry. The third division of these injuries is that known as the intra-articular or complicated. This is a fracture in which the break is not confined entirely to the process, but continues into, or runs through, the glenoid cavity or the subscapular fossa. (This is also seen in Fig. 3385.) Those of the latter class belong more properly to the subject of fractures of the scapula, and the reader is referred to the article Fractures, in vol. iii. of this HANDBOOK, for more thorough information upon the subject. From the foregoing arrangement it will be seen that fractures of this process correspond to the ordinary types of a like injury occurring in the other bones of the body.

History.—It will not be deemed necessary to sacrifice space to enter into a detailed history of this fracture. Du Verney, more than a century ago, called attention to its existence, and, only a few years later, among the first in this country to describe it was William Gibson, of Philadelphia. The latter recognized its importance in his "Treatise on Surgery" (vol. i., p. 258, 1835 edition), and mentioned two cases as having come under his own observation, in which this was the diagnosis arrived at. He records the first of his cases as occurring in the person of the famous Charles Carroll, of Carrollton, who, while riding in the carriage of the British Minister, Bagot, was upset, and by a violent fall upon the shoulder this process was broken off. Gibson remarks, "The subject being a remarkably thin one, I was able to distinctly feel and move the fragments one upon the other." Of his second case he makes no further mention than to say it was in the person of a sailor. The following reports of cases, though not arranged to illustrate any particular feature of these injuries, will be found to describe this fracture when resulting principally from falls and violence imparted to the humerus and the shoulder-joint as a whole. As an apology for entering the reports of cases

in a work like this, it can be said to best justify the general purpose of it, which is to present reliable information lucidly and briefly.

Case I.—A milk-woman, aged thirty years, fell from a cart upon her right side into the street. The motions of the arm were not impaired, she could raise her hand to her head without any difficulty. The clavicle, humerus, and acromion were entire, there was neither deformity nor flattening; but on attempting to grasp the coracoid process while the arm was freely moved up and down, a looseness and crepitus could be distinctly felt, and a grating was also perceptible in the axilla. The arm was secured to the side by means of a sling and bandage, and fomentations were applied. There was very little swelling, but the woman complained of pain which was increased by motion. (London *Lancet*, 1840–41.)

Case II.—Male, aged forty-five years, very thin and spare, fell down a steep flight of stairs feet foremost, striking heavily upon his left elbow, which was thrown backward in an effort to protect himself. Examination showed the arm shortened, elbow carried a little backward and slightly separated from the body; motion, especially forward, greatly restricted. To the inner side of the acromion was felt a prominence, which was the head of the humerus, dislocated but easily reducible. Crepitus was obtained by making traction upon the arm and carrying it outward and forward; this crepitus was felt by the thumb when placed upon the coracoid process, and was plainly marked, though consisting of but a single click. Pain was localized at the point of crepitus. (Taken from Streeter's case, *Medical Record*, 1887.)

Case III.—Male, aged twenty-four years, fell down an open hatchway of a vessel, some twenty feet. The right hand at the time of the fall was in the pocket of his trousers. The injuries were fatal, and a dissection disclosed a fracture of the coracoid process. The line of fracture ran obliquely from the inner and upper border of the process, just beyond the attachment of the coraco-clavicular ligament, downward and outward toward the tip, and terminated on the external border, a fourth of an inch from its summit. There was no displacement of the fragment, the head of the humerus was dislocated forward, and at the moment of its passage from the glenoid cavity the upper portion had fractured the process by pushing against its under surface. (Bennett: *Dublin Journal of Medical Science*, 1873.)

Case IV.—Male, aged seventy-six years, fell, striking his right shoulder against a projecting board. . . . The right arm was powerless, the shoulder somewhat swollen, and there was a contusion one and a half inch below the acromion, and slightly to the posterior side of the humerus. Movement was very painful, and occasional crepitus could be distinctly felt when the arm was rotated. The head of the humerus was thrown a little forward and inward, but readily answered to all movements imparted at the elbow. No pain or crepitus was found over the clavicle, the acromion was intact, and there was no break about the glenoid cavity. There was unmistakable bone crepitus, and pain was felt over the coracoid process. (Johnson: *Medical News*, 1885.)

Case V.—Elderly woman, who slipped down in a narrow alleyway and struck her elbow, driving the head of the humerus forward. The symptoms were loss of function of the coraco-brachialis and pectoralis minor muscles, tenderness, and crepitus on pressure of the coracoid process. (Packard: *Charleston Medical and Surgical Journal*, 1859.)

Case VI.—Male, aged thirty-three years, slender build, scanty adipose tissues, bony landmarks prominent. The patient had recently undergone an amputation of the forearm a few inches below the elbow, the stump remaining unhealed and tender. He was found supporting his stump with the opposite right hand, nervous, pale, and evidently suffering intense pain. The information was that, while endeavoring to avoid the wheels of a vehicle in the street, he had lost his footing and fallen backward into the gutter; in doing so he had, to use his own words, "knocked his shoulder out of joint." Further questioning as to the exact manner of the accident elicited the fact that, while falling, he had struggled to recover his lost equilibrium, and, as a consequence, landed heavily and awkwardly upon his left shoulder.

The arm, it was ascertained, had been raised above the head and thrown outward, possibly instinctively as it were, to protect the sensitive stump, and in this position the bulk of the traumatism from the fall was sustained by that portion of the shoulder corresponding to the space between the deltoid insertion of the humerus and the dorsal aspect of the acromion. Upon exposing the limb for inspection it was found to hang lower than its opposite fellow, the elbow being held away from, and slightly to the front of, the body. The hand, in passing carefully along the clavicle, acromion, scapular spine, and head of the humerus, then into the axilla and the space corresponding to the coracoid process, detected no anomaly, excepting a slight subluxation forward of the head of the humerus. A little extension reduced this to position, and, the parts presenting their normal contour, the patient was assured that everything was in its place and nothing broken. Notwithstanding this assurance he continued, with considerable misgivings, to complain of severe pain. In order to convince him, the arm was immediately put through several brisk manipulations, as if nothing was the matter; while carrying the limb outward and rotating, distinct crepitus was heard, which the patient was quick to notice, and remarked that he "felt it grate, and something must be broken." A careful repetition of these movements, with the fingers pressed gently into the coracoid space, revealed the irregularity there. Any increased pressure from the fingers while the limb was moved, caused crepitus, and so augmented the pain that the patient energetically protested against its being repeated, flinching each time the process was touched. He was then directed to shrug the shoulder, and was unable to do so. This peculiar movement of shrugging the shoulders (*hausser les épaules*) has not been before alluded to by writers when discussing this injury; it is, however, of considerable value as an element in diagnosis. It will be recalled that the pectoralis minor muscle draws the scapula forward and downward, and at the same time causes it to execute a rotating motion, by virtue of which the inferior angle is carried backward and the anterior depressed; if the arm be fixed the coraco-brachialis assists these movements, and in order to perform them it is necessary that the entire set of ligaments of this process should be in an intact condition. If a fracture be present in which there is separation of the fragments, with an alteration in the position of the ligaments, these combined movements cannot take place. In this case the arm was elevated and abducted; the force was severe, the whole weight of the body striking the curbing, and the head of the humerus, in partial dislocation, was directed against the process. There were localized pain and crepitus, with swelling and a suspension of the function of the muscles corresponding to the parts. (Byers: "Coracoid Fractures," pamph., 1885.)

There is little doubt, in this case, that when the head of the humerus was driven forward it pressed forcibly against the process, and caused rupture of the coraco-acromial ligament, the fracture being produced by one bone striking against the other.

Allen says: "The coracoid process acts as a check to this inward movement of the head of the humerus, and, unless it be broken off, subclavicular dislocation can scarcely occur." Rotation of the head of the humerus outward, in a great many of the cases reported, produces crepitus, and appears at the same time to effect a reduction of the piece broken off. The mechanism of this crepitus and restoration of the fragment has not been satisfactorily explained. The late Dr. Hamilton, upon one occasion, saw an instance in which the apex could be replaced, but how and upon what principle he confessed his inability to state, unless perhaps it was by drawing upon the muscle attached to the process. The most plausible explanation, however, would appear to reside in another and entirely different source, namely, traction exerted by the accessory ligament. This arises from

the outer border of the coracoid and passes over across the capsular ligament—being partially blended with its fibres—and is inserted into the greater tuberosity of the humerus. It can now be seen that tension upon this ligament, caused by outward rotation, will produce results directly opposite to the ordinary action of the muscles mentioned. The action of the muscles is to displace downward, while traction exerted upon the accessory ligament lifts and carries the process outward.

The foregoing cases are found to illustrate this fracture chiefly when it occurs as the result of violence imparted to the humerus, this being by its displacement the principal factor in its production. Some cases will now be presented to show how it may be a consequence of violence applied to the process directly from the front. These two causes are found to be the most important ones in a large number of these accidents. The opinion has been entertained that force applied to any portion of the scapula, and especially from the front, would cause it to rebound upon its muscular supports, and that this would so mitigate the force as to render it virtually incapable of fracture. Agnew is of the opinion that the head of the humerus alone is capable of fracturing even the glenoid cavity when forcibly driven against it. That the hypothesis of its being protected by the muscles is not consistent with experience, will be seen from a study of the cases that follow:

Case I.—Male, aged twenty-seven, fell in the dark, striking his shoulder against the edge of a door standing ajar. The pain was excessive, so much so as to render him unconscious for some little time. Upon a careful examination of the part no objective signs of the injury were at first evident. There was inability to place the hand upon the head, and also extreme tenderness on pressure, limited to a space just inside of the acromial end of the clavicle and just below it. No crepitus was at this time present, nor was there deformity. Next day there was tumescence, circumscribed to the injured spot, with impairment of the functions of the muscles attached to the process, and crepitus was now plainly perceptible over the seat of the injury. (Huse: *Chicago Medical Examiner*, 1879.)

Case II.—Male, aged sixty-six, while walking along the street was struck full on the right shoulder by a runaway horse, lifting him bodily off his feet and violently throwing him against an iron column. Upon making an examination, pain was found about the shoulder, very severe, the patient complaining that his arm was broken. But no false point of motion was found until the coracoid process was reached. Manipulation here caused exquisite pain; some crepitation was made out, and there was a slight degree of displacement. (Borcheim, in *Atlanta Medical Journal*, 1886.)

Case III.—Male, aged fifty-six, stout farmer, thrown down by a colt and kicked badly. Examination showed no displacement nor fracture, until by chance crepitus was noticed at a point in front of the right shoulder. The humerus was in place, and every motion of the arm could be made passively, the spine of the scapula and clavicle were entire, the crepitus being strictly localized to a point internal to the shoulder-joint and beneath the clavicle. (Higgins: *Philadelphia Medical News*, 1885.)

Case IV.—Male, laborer, of intemperate habits, was struck by a plank falling from a great height, the point striking him full upon the tip of the shoulder. The arm hung helpless by the side of the body. The adjacent bones were all entire, crepitus was felt by manipulating the arm, and motion of a loose fragment could be detected on examination through the axilla; the line of fracture probably extended into the glenoid cavity. (S. W. Smith, N. Y., unpublished case.)

Agnew and Hamilton have each observed cases in which violence, as a blow in front, was a cause.

Diagnosis.—The detection of this injury may at times be a matter of difficulty, especially when the presence of other complications more important, such as swelling, dislocation, and other fractures, masks it. The history, with a knowledge of the kind and direction of the force, will frequently be of material service in its recognition. Crepitus can usually be produced by outward rotation of the arm, and mobility of the fragment is occasionally seen and felt; localized pain and tumefaction, with an inability to shrug the shoulder, and an absence of other injuries capable of producing analogous symptoms, are further aids to diagnosis. These will usually lead to a correct solution of the difficulty, should any be presented. Holden, in his valuable "Landmarks," says: "On the front surface of the clavicle, not far from the acromial end, there is, in many persons of mature age, a spine-like projection of bone. This is liable to be confounded with the coracoid, and it would be well to examine the opposite side to see if there is a corresponding projection also, in order to clear up any possibility of error from this source.

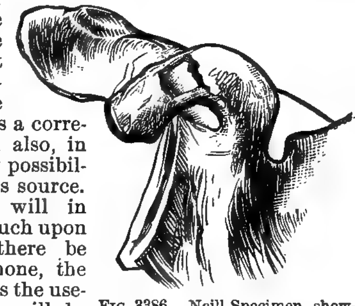

Fig. 3386.—Neill Specimen, showing Process Reunited by Two Parallel Fibrous Bands.

Prognosis. — This will in most cases depend much upon complications, if there be such; if there be none, the final result as regards the usefulness of the limb will be good, and assurances may be generally given to this effect.

The exact seat of the fracture, as compared with its ligamentous arrangement, will be a matter to be determined, if it is desired to obtain perfect union. If the fracture is in immediate proximity to the base, and if the acromial and clavicular ligaments are also ruptured, we certainly shall expect to find very marked displacement of the broken fragment. This will be evidenced by an unusual degree of passive mobility, and by a more or less total suspension of the functions of the corresponding muscles. The union, as a consequence, will necessarily here be by an intervening fibrous band, since no sort of retentive apparatus is capable of acting as a perfect splint in these circumstances. Again, if the break be anterior or between the ligaments, and if their clavicular and acromial attachments escape rupture, the area of displacement will be materially abridged. If the process be broken in such a manner as to hinder or prevent its easy reposition and retention—as when the base is drawn down and tilted forward, or when there are spasms of the muscles—the union will be fibrous, and there will doubtless also be a permanently movable process. This condition is shown in Fig. 3386, and is the common sequence in a majority of cases. Hamilton mentions several examples in which the process could be moved months after the accident. These movable processes will occur in all those cases where the bones have been widely separated, and where there has been a failure to retain the surfaces in proper apposition during the reparative effort. However, this fibrous or ligamentous union does not mar the ultimate usefulness of the process, the shoulder usually presenting nothing uncommon excepting, at times, an awkwardness observable solely by the patient. Many of the specimens contained in museums show ligamentous union as a result, but very few manifest anything like an attempt at genuine osseous deposit, this being rare. Fig. 3387 is taken from a photographic plate in the possession of Marcy, of Boston. The specimen is to be found in the

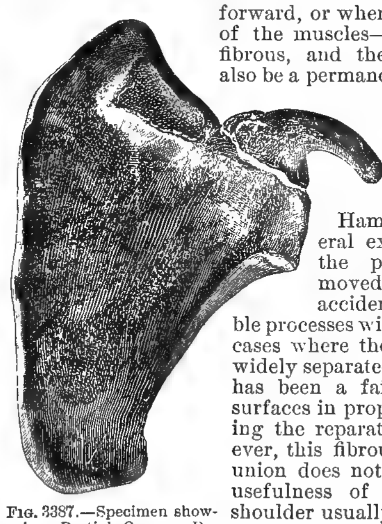

Fig. 3387.—Specimen showing Partial Osseous Deposit. (Warren Anatomical Museum, Boston.)

No.	Sex.	Age.	Cause.	Evidence.	Complication.	Reference.	Results.	Side.
1	Male.	45 years.	Fall backward.	Pain, crepitus, swelling, and mobility of process.	There was some, but not stated.	Dr. F. B. Streeter, Med. Record, vol. i., 1887.	Not stated.	Left.
2	Male.	66 years.	Thrown bodily against an iron column.	Pain, crepitus, and mobility of process.	There was some, but not stated.	Dr. L. E. Borcheim, Atlanta, Ga., Med. and Surgical Journal, 1886.	Not stated.	Right.
3	Male.	33 years.	Fall backward.	Pain, crepitus, mobility, and loss of function.	Subluxation forward of head of humerus.	Dr. J. Wellington Byers, pamphlet, 1885.	Ligamentous union.	Left.
4	Male.	56 years.	Kicked by a horse.	Crepitus, pain, and mobility of process.	Not stated.	Dr. F. W. Higgins, Phila. Med. News, Dec., 1885.	Union by ligaments.	Right.
5	Male.	Adult.	Patient crushed by falling masonry.	Post-mortem dissection.	See illustration of greenstick fracture, Fig. 3385.	Bennett, Trans. Academy Med., Ireland, 1883.	......	Left.
6	Male.	Adult.	......	Post-mortem dissection.	Tip seen suspended by the clavicle ligament.	Wood's Museum, N. Y., Specimen 455.	No attempt at repair.	Left.
7	Female.	Elderly.	Fall upon elbow.	Pain, crepitus, and loss of function.	Head of humerus dislocated forward and upward.	Dr. J. H. Packard, Charleston Med. Journal and Review, 1859.	......	Left.
8	Male.	Adult.	Unknown.	Post-mortem.	Fragment hangs loose.	Wood's Museum, N. Y., Specimen 475.	No attempt at repair.	Left.
9	Male.	Adult.	Gunshot.	Post-mortem dissection.	......	Army Med. Museum, Washington, D. C.	Osteitis, with spontaneous separation.	......
10	Male.	55 years.	Fall upon shoulder.	Pain, crepitus, and mobility.	......	Gibson's Surgery, edit. 1836, vol. i., p. 258.	......	......
11	Male.	Adult.	Struck by an iron bar.	Pain, prominence of process.	Dislocation of head of humerus.	Agnew's Surgery, vol. i.	Ligamentous union.	......
12	Male.	......	......	Post-mortem dissection.	Fracture of glenoid and base of acromion.	Erichsen's Surgery, vol. i.	......	......
13	Female.	14 years.	Fall.	Mobility and crepitus.	......	Paule's case, Bryant's Surgery, 4th edit.	......	......
14	Male.	Adult.	......	Post-mortem dissection.	......	Neill specimen, see Fig. 3386; also Agnew's Surgery, vol. i., p. 876.	Ligamentous union.	Right.
15	......	Adult.	......	Post-mortem dissection.	......	Gibson, Agnew's Surgery, vol. i., p. 876.	Union by ligament.	......
16	......	......	Muscular action.	......	......	Lancet, London, 1873.	......	......
17	......	......	Fall forward.	......	Not stated	Holmes' Surgery, vol. i.	......	......
18	......	......	......	......	Dislocation of humerus, clavicle fractured.	London Med. and Surg. Review, 1840.	......	......
19	......	......	......	Post-mortem dissection.	Dislocation of humerus.	Hamilton, Fractures, 7th edit.	......	......
20	......	......	......	......	Fract. acromion and humerus.	Cooper, Fract. and Dislocation.	Union by ligament.	......
21	......	......	......	......	Broken twice and glenoid involved.	Hamilton, Fract. and Dislocation, 7th edit.	......	......
22	Male.	Adult.	......	Post-mortem dissection.	See Fig. 3387.	Marcey, Trans. Am. Med. Ass., 1885.	Partially osseous union.	......
23	......	......	......	Post-mortem dissection.	Severe damage to the soft parts.	Archives Générales de Méd., 1840.	......	......
24	......	......	......	Post-mortem dissection.	......	Malgaigne, Fract., Packard's Trans.	Ligamentous union.	......
25	......	......	......	Post-mortem dissection.	......	Malgaigne, Fract., Packard's Trans.	Ligamentous union.	......
26	Male.	Adult.	Gunshot.	Post-mortem dissection.	......	Army Med. Museum, Washington, D. C.	No effort at repair.	Right.
27	Male.	Adult.	......	......	......	Gibson's Surg., vol. i., 1836.	......	......
28	Male.	Adult.	Muscular action.	Post-mortem dissection.	Osteomalacia.	Bennett, Dub., case not published.	Osseous union by unbroken periosteum.	......
29	......	......	......	Post-mortem dissection.	......	Fergusson's Surg., p. 231.	......	......
30	......	......	......	Post-mortem dissection.	......	Malgaigne, Fract. and Dislocation.	......	......
31	Male.	30 years.	Fall.	Crepitus, displacement, mobility of process.	Shock.	Phila. Med. News, No. 671, Nov., 1885.	Bony union (doubtful).	......
32	......	......	......	......	......	Med. and Surg. Trans., vol. xli., p. 447.	......	......
33	Male.	Adult.	......	Post-mortem dissection.	Horizontal fracture of scapula.	Dr. T. E. Little, Dub. Jour. Med. Sci., 1879.	Ligamentous union.	......
34	Male.	Adult.	......	Post-mortem dissection.	Unreduced dislocation of humerus forward.	Notes by Dr. R. W. Smith, of Dub., case not published.	Ligamentous union.	......
35	Female.	16 years.	Blow.	Crepitus, pain, and displacement.	......	Bryant's Surg., third Am. edit., p. 829.	......	......
36	Male.	35 years.	Fall.	Post-mortem dissection.	Dislocation of the head of the humerus.	Bennett, Dub. Jour. Med. Sci., 1873.	......	Right.
37	Male.	Adult.	Plank falling upon shoulder.	Pain, crepitus, loss of function.	Supposed fract. of glenoid cavity.	Dr. S. W. Smith, of New York (Case IV., on p. 300).	......	Right.
38	Female.	32 years.	Fall.	Pain, crepitus, and loss of function.	Wounds of face.	London Lancet, 1840–41.	......	......
39	Male.	27 years.	Fall forward.	Pain, crepitus, and loss of function.	Loss of consciousness.	Huse, Chicago Med. Jour., August, 1879.	......	......
40	Female.	15 years.	Fall.	Mobility and crepitus.	Dislocation of the clavicle.	Hamilton, Fract. and Dislocation, 7th edit.	......	......
41	Male.	76 years.	Fall.	Crepitus, pain, and impaired function.	Humerus subluxated forward.	Dr. R. W. Johnson, Phila. Med. News, 1885.	Osseous union.	Right.
42	Male.	Adult.	Struck by a board.	Preternatural mobility 3 months after injury.	Dislocation of the outer end of the clavicle.	Hamilton, Fract. and Dislocation, 7th edit.	Ligamentous union.	......
43	Male.	38 years.	Struck by an iron rod.	Crepitus and displacement.	Paralysis of arms and hand.	Hamilton, loc. cit.	......	......
44	Male.	Adult.	Fall forward.	Mobility and crepitus.	......	Holmes, System Surg., vol. i.	......	......

Warren Museum of the same city, and is catalogued as No. 983, deposited by Warren, 1847. An examination of it shows that the edge of the fracture, which extends into the glenoid cavity, has undergone no effort at repair, yet, upon the superior border of the neck, there is an abundant formation of new bone, filling the suprascapular notch, and extending along a fissure running nearly the whole extent of the supraspinous fossa. Bennett mentions a case in which the result was osseous union and unbroken periosteum, as was shown at the post-mortem examination. Two other cases, by Drs. Alan Smith and R. W. Johnson, of Baltimore, have been reported, but not confirmed, however, by autopsies.

Treatment.—This can be set forth briefly and in a very few sentences. The indications, in the light of what has been already stated, are plain. Usually we should endeavor to restore the part broken off to as near its original position as is possible, and to retain it there by means of suitable apparatus. This can best be accomplished and the requisite indications fulfilled by first relaxing the muscles causing displacements. To effect this the forearm should be flexed, and rotated outward, bringing the fragment back to its normal position; then the arm, still flexed, should be carried across the chest and secured there by means of a Fox apparatus, a Velpeau, or a four-tailed bandage.

It is advisable to combat the inflammation that sometimes follows in the loose cellular tissue by anodyne lotions. The effusions are abundant when they take place, frequently reaching to the elbow. The apparatus should be worn for six weeks, when osseous union may be expected. At first the muscles should be used carefully.

Remarks.—To summarize these reports of cases and the tables that are shown on preceding page, it will be seen that in all those which were not fatal there were associated with the fracture changes in the head of the humerus. Pain and crepitus are the most frequent symptoms met with. One-half of all the cases tabulated were verified by post-mortem dissections, these being principally reported by the older authorities; whereas nearly all of the recent cases were diagnosed and clearly illustrated by the symptoms during the life of the subject. Of those not terminating fatally, seventy per cent. were the result of falls. No particular manner of falling seems essential for the production of this injury, since it is seen to occur while the arm is elevated, abducted, thrown backward, or by the side, the body falling either backward, forward, or sideways. Flower saw two cases in which the hands were stretched forward during the fall. Twenty-five per cent. of the cases occurred in adult males, five were women and young girls, the sex of the remainder being undetermined. The ages will be found to extend from fourteen to seventy-six years, a large per cent. certainly occurring after a consolidation of the epiphyses; the only cases showing any liability toward criticism from this source are those of Bryant, Paule, and one of Hamilton. The Neill specimen has been objected to on account of this, but the scapula is large, well-developed, and doubtless came from an adult. As to this fracture being confounded with separation of the epiphyses, this term is only applicable when the line of fracture is identical with the remaining interosseous cartilage, which during the years of adolescence merges into the bone of the scapula proper. Separations of this bone are only possible prior to the twenty-fifth year, unless, as a result of some malformation or disease, the cartilaginous medium has persisted later in life. Therefore the attempt of some to pronounce all these injuries as merely separations of the epiphyses, rather than true fractures, is unwarrantable. As to direct violence being the principal cause of this injury, as is generally taught, an examination of fifty examples shows that this was the means in only six cases. Two cases are reported as the result of muscular action, but these, it is fair to assume, were associated with osteomalacia or other diseases. Gurlt's "Knockenbrücher" is said to contain a description of about twenty cases of coracoid fracture.

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J. Wellington Byers.

SCARBOROUGH, a city of about thirty-five thousand inhabitants, on the east coast of Yorkshire, is one of the best known and most popular of English watering-places. There are two mineral springs here, which are known as the North Well, or iron spring, and the South Well, or saline spring. The following are the analyses of these two springs, made by Phillips (Rotureau). In 1,000 parts of water there are of

	North Well.	South Well.
Sodium chloride	2.016	3.140
Ferrous bicarbonate	0.210	0.192
Calcium bicarbonate	5.517	5.066
Calcium sulphate	11.877	11.713
Magnesium sulphate	19.734	23.884
Total	39.354	43.995

The waters of Scarborough are used to some extent in therapeutics for the same purposes as are other saline and ferruginous springs, being prescribed especially for those suffering from anæmia who are also troubled with constipation. But the visitors are, as a rule, attracted more by the fine sea-bathing than they are by the springs.

T. L. S.

SCARLET FEVER. Synonyms: Scarlatina (English and Italian); Scharlach (German); Scarlatine (French); Escarlatina (Spanish).

Definition.—Scarlet fever is an eruptive contagious fever. Its incubative period is brief, rarely less than twenty-four hours, usually lasting from four to six days, and not often exceeding this duration. This period is succeeded by a period of invasion which is ushered in by fever, usually of considerable intensity, and by sore throat. A scarlet eruption begins to appear before the end of the second day, and marks the end of the prodromal, and the beginning of the eruptive, period. The eruption rapidly becomes general, and the tongue becomes stripped of its coating and assumes a raspberry-red color. The eruption slowly fades after the first few days. The fever persists until the sixth, seventh, or eighth day, or longer. As the eruption fades, desquamation begins and continues for from eight to fourteen days or more. It is peculiar in being lamellar, sometimes occurring in very large shreds and exfoliations. During the attack, and for weeks subsequently, there is an especial predisposition to renal inflammation. Scarlet fever attacks children more especially. It usually affects an individual but once.

History.—Scarlet fever is probably a disease of very ancient origin, though until three centuries ago medical writers had not recognized it; indeed, definite knowledge of it as a specific, independent affection dates back hardly two hundred years, although as early as 1589 an epidemic, which we now presume to have been scarlet fever, was described as having occurred in Sicily in 1543 (Paulus Restiva).[1] It was not until 1676 that Sydenham definitely separated this malady, as "*febris scarlatina*," from measles, and gave it an established position. The observations of writers had already been leading them toward similar views, and within a few years scarlatina became recognized all over Europe. Although its place of origin can never be known, it is probably of European birth; for it is a remarkable fact that scarlet fever has never succeeded in gaining a firm foothold in Asia or Africa. According to Hirsch, in whose most

valuable work these facts have been recorded, the coast of Asia Minor is the only Asiatic district which is frequently visited with scarlatina in its severe forms. In nearly all other parts of Asia it occurs not at all, or only sporadically. Wernich, in 1871, declared the disease to be quite unknown there. In Africa, Hirsch states that it is only in Algiers and in the Azores that it is at all common. Following the carefully recorded data of Hirsch, scarlet fever appeared first in America, in New England, in 1735. It extended as far south as Philadelphia in 1746, and penetrated to Ohio in 1791. Not until 1851 was it seen in California. In 1830 it began to be generally observed in South America. In the West Indies it was first observed in 1802, in Martinique, as a mild epidemic. Greenland has heretofore escaped with but a solitary case. Australia and Polynesia appear to have escaped until 1848. In the Polynesian islands, except Tahiti, scarlatina has not been known. It is unquestionable that scarlet fever has never occurred in some localities only because the inhabitants have not been exposed to its influence; but there can be no doubt that in other countries influences prevail that oppose the development of the disease. Whether these are climatic or racial, or due to other causes, is at present unknown. The American Indian is not exempt from its ravages, nor can any different degree of susceptibility be observed in the negro race in the United States. Frick,[2] however, noted a somewhat more pronounced tendency in the negro to scarlet fever. In the epidemic in Baltimore, between the years 1850 and 1854, of every ten thousand inhabitants 13.8 whites and 10.8 negroes died. This would indicate a relatively greater predisposition in the negro, as in the total population the whites were largely in the majority. Frick's observations were too limited to secure an unhesitating acceptance of his conclusions. It must be noted, however, that in this country the negro is rarely of unmixed African descent. He may have inherited from white progenitors some of their especial liabilities to disease. Drake and others have shown that scarlet fever prevails less in the Southern than in the Northern States. It is also probably true that the disease is more frequent in cold than in hot countries. Yet it cannot be determined that the differences depend upon temperature; Greenland has remained without an epidemic, while Algiers has experienced them frequently.

Scarlet fever at once shows differences from small-pox and measles in not sweeping over localities in great periodic waves. It may, it is true, sometimes invade very wide areas of territory with astonishing rapidity, but the intervals between epidemics are often very great. Without obeying any well-defined periodic law, measles is often known to prevail with noticeable violence every third or fourth year, frequently disappearing completely in the interim: so, too, small-pox usually exhibits unwonted activity at intervals of from five to ten years, or as soon as popular neglect of vaccination renders a large portion of a community susceptible to it. It is not thus with scarlatina. Hirsch has collected very valuable information upon this point. At Münster fifty years elapsed without the disease appearing. At Ulm there was only one small epidemic in seventeen years. At Tuttlingen scarlet fever had not been seen for thirty-five years previous to the epidemic of 1862–63. A number of writers, however, *have* observed an epidemic cycle in scarlet fever. Thus Fleischmann,[3] at St. Joseph's Hospital, in Vienna, observed one of four years. In Dresden, according to Gerhart, there is an epidemic cycle of from four to five years; in Munich, according to Ranke, of three years. On the other hand, scarlet fever often prevails sporadically for a long time in a locality, finally to disappear or to spread suddenly far and wide. Mayr[4] states that in Vienna the register shows that scarlatina has never absolutely died out in fifty years. Scarlet fever is remarkable in the varying intensity of cases occurring during a given epidemic, and in the differing severity of epidemics. At one time it was regarded as an insignificant disorder, almost never proving perilous to life. Even now epidemics of an exceedingly mild type are frequent. Graves has told how, between 1800 and 1834, whenever scarlet fever prevailed in Dublin, it was so uniformly mild that medical men attributed the bad results of their predecessors to improper methods of treatment, and flattered themselves upon their superior skill, until a change in type brought their death-rate quite up to that of former times.

ETIOLOGY.—It is certain that scarlet fever has for its essence some active specific principle, which, conveyed by the atmosphere, or by fluids, or by mediate or immediate contact from one person to another, excites a peculiar morbid train of phenomena. Although, even recently, there have been those who maintain that it may be autochthonous, contemporary writers are unanimous in adopting the theory of a *contagium vivum* in its pathogenesis. The tendency of recent investigation has been to direct attention to certain low forms of vegetable life, belonging to the schizomycetes or bacteria, as the probable cause of this class of specific diseases. It is altogether probable that they maintain a similar relationship to scarlet fever. As yet, however, they have not been identified with certainty. Carpenter, who claimed that the disease may arise *de novo*, asserted that it then results from germs of organic matter which have been given off from vertebrate blood in a particular state of decomposition, and that the decomposition of blood in slaughter-houses is a frequent source of scarlatina. This view has not been successfully maintained. Coze and Feltz[5] detected in scarlatinous blood diplococci (sphærobacteria), and produced in rabbits by inoculation of this blood a fever-like disease. Riess[6] has had similar experience. Recently Löffler[7] has described chain-shaped cocci in the membrane of scarlatinal diphtheria. He claims that if these be introduced into a joint, inflammation soon develops; if simply beneath the skin, an inflammation like erysipelas results. Hallier[8] found in the blood of three patients a greater mass of micrococci than he has ever seen in any other infectious disorder. They were more numerous than blood-corpuscles, swimming free in masses united by a gelatinous envelope, in or on the corpuscles. Exceptionally the white cells, which were unusually numerous, were pervaded with micrococci. Hallier made culture experiments, and concluded that the blood of scarlatina patients contains a micrococcus of unknown nature, and proposed for it the name *Tilletia scarlatinosa*. Eklund[9] recognizes as the cause of scarlatina a micrococcus which he calls *plax scindens*. He finds it in the urine of scarlatinous patients, and describes it minutely. He has not found it in the urine of those who have not had scarlet fever, but has discovered it in the soil, on damp walls, on the margins of swamps, and in other places. Inoculations with *plax scindens* have not been performed, and, indeed, we can only wonder that anyone could be convinced by such insufficient evidence. More recently, Mr. George F. Cooke[10] has described a bacillus found in the nasal discharge and in the sero-purulent exudation from the inflamed lymphatic tissue of the neck in cases of scarlet fever. It occurred in leptothrix-like filaments. Pohl-Pincus[11] and Klamann[12] discovered micrococci in the scaling epidermis after scarlatina. Klein, in investigating the very important relations between scarlatina and a certain disorder in milch-cows, occurring at Hendon under the observation of Mr. Power (*vide infra*), discovered in the ulcers of the teats of affected cows a streptococcus which he was able to cultivate, and with it to successfully inoculate calves, producing a like affection. This streptococcus he also found in some condensed milk which was suspected to have caused an outbreak of scarlatina. He also succeeded in raising some colonies of the streptococcus in nutritive gelatine, etc., inoculated with human scarlatina.[13] Klein's investigations were of a highly meritorious character, and seemed to lead to the identification of the true micro-organism of scarlatina, but doubts of their accuracy have recently been raised by the results obtained by Jamieson and Edington, in Edinburgh, whose conclusions by no means tally with those of Klein. These authors,[14] after experiments and cultures performed under the strictest precautions and with the greatest care, describe

a number of organisms, of which *diplococcus scarlatinæ sanguinis* and *bacillus scarlatinæ* deserve especial attention. The former was found in forty-five per cent. of the cultures made from the desquamation, and in thirty per cent. of those made from scarlatinal blood. The specific cause of scarlet fever, however, is considered to be, by these writers, *bacillus scarlatinæ*. It was discovered "in every case but one of the tubes made from the desquamation, if taken after the termination of the third week, but never before this." It also occurred in every tube made from scarlatinal blood, if taken before the third day of the fever. While these various observations are of the greatest interest, they are so little in accord that one can hardly admit as yet that the pathogenetic organism of scarlatina has been definitely determined.

While we assume the exciting cause of the disease to be an, as yet, undetermined germ, in the presence of which alone scarlatina is possible, the question of the predisposing causes is a much wider one and demands careful consideration.

There is a widespread impression that scarlet fever prevails more especially during the fall and winter months. There is, indeed, some difference in favor of these seasons, but by no means to the extent that is generally supposed. Hirsch has tabulated the records of 435 epidemics. These prevailed 178 times in the winter; 157 times in spring; 173 times in summer; and 213 times in autumn. The same relative prevalence is shown in his tables of deaths from scarlatina. Of more than fifty-five thousand deaths from scarlet fever in London, from 1838 to 1853, 32.1 per cent. occurred in autumn; 25.2 per cent. in summer; 24.6 per cent. in winter; 22.1 per cent in spring. These figures, however, cannot be accepted with perfect confidence, as they must have been influenced by the mildness or severity of the several epidemics. Hirsch's data show also the season of prevalence and the severity of type for two hundred and sixty-five epidemics.

Of 77 winter epidemics	42.2 per cent. were	mild.
	55.8 " "	severe.
Of 50 spring epidemics	54 " "	mild.
	46 " "	severe.
Of 66 summer epidemics	45.5 " "	mild.
	54 " "	severe.
Of 72 autumn epidemics	48.6 " "	mild.
	51.4 " "	severe.

The maxima of malignancy fall in winter and summer; but, as Hirsch remarks, the difference is unimportant. It may be concluded, however, that in the spring epidemics are usually less frequent and milder.

Scarlet fever attacks nearly all of those who are exposed to its influence for the first time. It is chiefly observed in young persons, because older people are generally protected by a former attack. Nevertheless, adults who have never had scarlet fever are less liable to take it than children similarly circumstanced. This is not attributable to differences of age, but to feeble individual susceptibility, which probably held as well during the childhood of these persons. It is certain that a not very small percentage of persons successfully resist exposure to the scarlet-fever contagion throughout life. While, then, it is not difficult to understand why adults seldom take scarlet fever, it is more difficult to account for feeble predisposition observed during the early months of life. Infants less than a year old are rarely attacked, and often escape even when exposed directly and frequently. According to J. Lewis Smith, infants less than four months of age almost possess immunity. Murchison tabulated the ages of 148,829 fatal cases of scarlatina occurring in England and Wales, as follows, viz.:

Deaths under 1 year	6.7 per cent.
" between 1 year and 2 years	14.09 "
" " 2 " " 3 "	16. "
" " 3 " " 4 "	15.13 "
" " 4 " " 5 "	11.9 "
" " 5 " " 10 "	25.9 "
" " 10 " " 15 "	5.8 "
" " 15 " " 25 "	2.6 "
" " 25 " " 35 "	0.8 "
" over 35	0.8 "

Fleischmann's figures give 8 deaths of children under one year of age; 304 from one to four years of age; and 206 from five to twelve years of age. J. Lewis Smith[15] added 58 cases reported by Octerlony to 145 of his own, a total of 203 cases, from which he framed the subjoined table:

3 cases were under	1 year of age.
25 " " from	1 to 2 years of age.
43 " " "	2 " 3 " "
57 " " "	3 " 5 " "
53 " " "	5 " 10 " "
13 " " "	10 " 15 " "
3 " " "	15 " 20 " "
4 " " "	20 " 30 " "
2 " " "	30 " 40 " "

Children less than one year of age, therefore, possess no absolute immunity; indeed, scarlatina during fœtal life has been reported. Leale observed such a case, as did also Tourtual. Thomas records several cases occurring in the practice of others. Veit noted scarlet fever in a child fourteen days of age. Numerous similar observations, more or less trustworthy, have been recorded. On the other hand, Murchison saw two new-born infants remain healthy while their mothers suffered from scarlet fever. New-born children are so subject to cutaneous and other disorders that may readily be mistaken for scarlatina, that we may well demand the most definite testimony. Scientific exactness should require that a new-born child must be proven either to have served as the medium of contagion for others, or to have developed characteristic symptoms in the midst of predisposing surroundings. The third year is the one during which the most cases are probably encountered. Nearly ninety *per centum* of all cases of scarlet fever occur before the completion of the tenth year. Although the disease is rare in advanced life, it sometimes occurs. In Murchison's tables there are recorded ten deaths of persons over eighty-five years of age.

Barthez and Rilliet thought that boys were more often affected than girls. They were probably correct, though the difference is not great. Of 472 cases in St. Joseph's Hospital, in Vienna, Fleischmann states that 263 were boys and 209 girls. Barthez and Rilliet observed that scarlet fever rarely attacks tuberculous children. (Grisolle believed the same rule to prevail for the adult.)

The predisposition to scarlet fever is much less universal than that to measles and small-pox. While the two latter diseases will almost certainly attack all unprotected persons exposed to their contagion, scarlet fever often leaves unscathed persons who have been brought into the most intimate personal relations with it. It is consequently much easier to practise isolation with the hope of success. However, the immunity possessed by an individual, as shown by repeated exposures, may not prove perpetual, and well-marked, even fatal, scarlatina may follow a final exposure. A degree of immunity from scarlatina is sometimes exhibited in families, the members of which escape altogether, or have only light attacks. Unfortunately, on the other hand, a decided family predisposition to the disease is occasionally encountered, one member after another falling a victim to its virulence.

Careful observation has failed to show that predisposition to scarlet fever is especially favored by the nature of the soil or the state of the weather; neither can it be proven that the type of the disease is especially influenced by any ordinary surroundings, further than that conditions of life prejudicial to the maintenance of good health diminish the powers of resistance to the onset of the disease. It is important to remember that in the absence of the contagious principle no degree of filth, deprivation, dampness, bad ventilation or drainage, or exposure, no matter how injurious to general healthfulness, can serve as the starting-point for scarlet fever. Indeed, it is remarkable, considering the bad hygienic environment of the poorer classes, that between them and the rich there should be so small a difference in the degree of predisposition to, and in the relative mortality from, scarlatina.

To develop scarlatina an individual must, of necessity,

receive into his body the *materies morbi* derived from one who has, or who has had, the disease. In all cases the contagion must be communicated by the air, or in solids or fluids received into the body. It is probable that physical contact occurs but rarely between infected and unprotected persons, and that when it does occur, the danger of infection is due rather to the increased liability of intercepting emanations from the body. Scarlet fever appears to be not contagious at the very beginning. In this respect it differs markedly from small-pox and measles. In the prodromal stage the contagion is probably not set free as readily as at a later period. Girard, however, has asserted that it is contagious only on the first day. This hardly needs a refutation. Longhurst[16] also claims that it is most contagious during the pre-eruptive stage, and not at all during desquamation. These and similar opinions of individuals are negatived by the almost universal experience of observers. Scarlet fever develops its highest properties of contagion during its period of eruption, and, still unlike measles, retains its contagiousness until desquamation is far advanced. Two children, at the Netherfields Institution at Liverpool, were believed to have been centres of contagion six and a half weeks after the beginning of their illness.[17] Cameron[18] reports a case in which, nearly nine weeks after the beginning of her own attack, a child communicated the disease to her sister by contact. It seems probable that the power of communicating scarlet fever is retained, gradually diminishing in intensity, until the end of desquamation, which may not be completed for six, eight, even ten weeks. Thomas mentions cases where children, even after the completion of desquamation, while suffering from scarlatinal dropsy, probably served as centres of contagion. The agency of the atmosphere as a contagion-bearer does not seem to extend beyond a few yards. Thus, it often happens that the disease does not spread beyond the sick-room, provided mediate contact can be avoided. Possibly the contagion is of too great gravity to be wafted for any distance. Yet it is certainly, under certain conditions, very tenacious of life, and may be conveyed long distances and preserve its properties for prolonged periods. It has often been carried by a healthy person, who has been exposed to the malady, to persons at a distance. There are authentic accounts of physicians, nurses, attendants, and visitors serving thus to carry infection. Such unfortunate occurrences are not very common, and probably only happen when the carrier of contagion passes directly from the sick-bed to the unprotected person, without due regard to the proper disinfection of the person and clothing. A pernicious custom is the habit of putting on over-clothing and wraps over the dress in which the patient has been visited, without proper exposure to the free circulation of fresh air. The tenacity with which the contagion clings to inanimate substances is most remarkable. Articles of clothing, bed-linen, furniture, wall-paper, hangings, and the like, frequently serve to communicate the disease, and often after almost incredibly long intervals. Richardson gives an example of this. Four children lived with their parents in a thatched cottage. One child was taken with scarlet fever, and the others were sent away. After three weeks one of these was permitted to return. It took the disease on the first day and died. The walls of the cottage were now cleaned and whitewashed; everything was thoroughly scrubbed, and all wearing apparel was washed or destroyed. After four months another child returned. The next day he was seized with the disease and died. Here the thatch was thought to have retained the contagion. The germs of the disease may be shut up in a letter and conveyed a long distance. Woollen clothing, put away and brought out after many months, pillows, cushions, toys, books, have all been known to preserve the contagion in full vigor. The dissemination of the virus in the atmosphere has been stated to be very limited, but the same cannot be said so confidently concerning the agency of fluids. The spread of scarlet fever has never been directly traced to the water-supply, but there is abundant reason to attribute its occasional extension to the medium of milk. Thomas quotes two examples of this. One, reported by Bell, leaves it an open question whether the milk, its receptacle, or the boy who carried it, was the medium. The other came under the observation of Taylor, who noticed "that one of the first severe cases which initiated an epidemic occurred in the house of a milkman whose wife milked the cows, the milk being supplied to about twelve families in the city. In six of these scarlatina occurred in rapid succession, at a time when the disease was not epidemic, and without any communication having taken place between those who were affected and the person who brought the milk. It is very probable that in this instance the milk was the carrier of the contagion, as, previous to its distribution, it had stood in a kitchen which had been used as a hospital for scarlatina patients." More recently, Airy, in eighteen families, consisting of thirty-five persons, reported twenty-four of these sick with scarlatina within thirty-six hours. Every one of these patients received milk from the same source. Neighbors who had milk from other sources were not attacked. It was found that a person who milked the cows lived with a child in full desquamation from scarlatina. Several observations of this kind make it hardly doubtful that milk may serve as the vehicle for the scarlatina virus, and that it, indeed, may be considered a favorable culture-fluid for it. But until recently it has not appeared that the virus-bearing milk received its contamination otherwise than through human sources. Later investigations seem to throw much light upon the possible origin of scarlatina in man, and upon one of the paths for its dissemination previously unrecognized. A recent outbreak of scarlatina among persons who received their milk-supply from a dairy in Hendon, in England, seemed to be traceable directly to a disease of the cow. The cows of this farm were affected with a peculiar affection, among the symptoms of which were a shedding of the hair and the formation of vesicles and ulcers upon the teats and udders. This is an inoculable disease among cows.* In this connection it is an important fact that inoculation of cows, especially when in milk, with the virus of scarlatina, results in the production of definite symptoms. The reports upon these observations by Mr. Power, Dr. Cameron, and Dr. Klein will go far toward establishing the prevalence of a scarlatina in cows, and its fruitfulness as a cause of the spread of scarlatina to mankind. Further information upon this most important subject will, doubtless, be soon forthcoming.

The scarlatinal virus gains access to the blood through the respiratory tract, and is also conveyed in solid and liquid food to the stomach, whence it is absorbed. Though it is unlikely that absorption can occur through the sound skin, the disease is said to have been inoculated by artificial deposition of contagion-bearing material upon the abraded cutis. Miguel d'Amobise claimed to have inoculated children successfully with blood taken from scarlatinous patches. Stoel and Harwood have been reported as having conducted successful inoculations. On the other hand, Petit-Radel failed in his experiments. New observations upon this point are required. The contagion probably resides in the epidermis, and becomes diffused as this is exfoliated; also in the buccal and faucial mucous membranes, and probably in the secretions, in the lymph, and in the blood. In the absence of reliable inoculation experiments we have no fixed knowledge upon these points. Some writers deny that the exfoliated epidermis contains any virus whatever.

Clinical History.—*Incubation.*—Scarlet fever has a shorter and much less definite period of incubation than the other eruptive fevers. In determining the interval between infection and the outbreak of symptoms, it is much easier to reach correct conclusions when the fever has followed a single exposure than when the exposures have been repeated or prolonged. There is abundant evidence to show that the period of incubation may be less than twenty-four hours. On the other hand, it has been

* The existence of scarlatina among animals has been ably upheld. Salmon's and Peters' papers upon equine scarlatina are very important.

claimed that four or five weeks may elapse before the disease manifests itself. Most cases of scarlatina have an incubation period of from four to seven days. Even this wide limit, differing markedly from that of the other eruptive fevers, is subject to very many exceptions, and the literature teems with examples of scarlet fever developing a few hours after exposure, or only after many days, even weeks. Murchison believed the incubation period to be more often less than forty-eight hours in duration. The shortest authentic stage of incubation was in the case of Richardson, who after auscultating a scarlet-fever patient immediately became nauseated and chilly. He was conveyed home in the carriage of a friend, and dated an attack of scarlatina from that hour. Incubative periods of not more than twenty-four hours have been reported by many writers.[19] In 20 cases Dukes found the duration to vary from one to nine days, in 10 cases it was less than five days. Murchison reported, in the "Transactions of the Clinical Society,"[20] the incubative periods of 75 cases, none of which exceeded ten days. He considered a person safe from contagion who is not attacked within a week after exposure. Thomas[21] thinks that from four to seven days is the most frequent interval; Kaposi considers it to be about eight days; Gee thinks that seven days are rarely exceeded; Lewis Smith, that it is ordinarily less than six days. Longer intervals, however, are not infrequently noted. In one case Hagenbach[22] determined it to be eleven days; in another, fourteen days. Intervals of twelve days or more have been recorded by Veit, Paasch, Böning, Lewis Smith, and others. From the rather untrustworthy results of inoculation, seven days would seem to have been the incubative period. Barthez and Rilliet, Gee, and others thought they had observed cases where the incubative period covered several weeks, and, indeed, in delicate children, especially those with rickets or other neuroses, it may be much prolonged (Mayr). There is, however, a growing belief that the incubation of scarlet fever lasts less than six days, and, without attempting to be more accurate, we accept that as the common duration. It is very often less than this, and but very seldom more. In this, as in most other features, scarlet fever shows great variability, and, if the term be allowable, a capriciousness contrasting strongly with the other specific fevers.

Period of Invasion.—For convenience of description it will be proper to describe scarlatina as following an *ordinary* or *mild*, and a *graver*, course. The course is very often irregular, from the absence of characteristic symptoms, or from the undue prominence of one or several of them, or from the presence of complications. In fact, scarlet fever may vary from an insignificant, even an unappreciable, disturbance of health, to a malady pursuing its fatal course with lightning-like rapidity; and although the type of the prevailing epidemic may be mild, severe, or malignant, individual cases can only in a measure conform to the standard, from which they will invariably differ to a greater or less extent.

Milder Forms.—Ordinary Course.—Prodromal Period. At the end of incubation the active symptoms of scarlet fever usually develop suddenly; rarely they appear more gradually. In most cases fever is the first symptom observed. In larger children and adults an initiatory chill is often noted. Convulsions may occur at the outset; usually, however, they usher in graver forms of the affection. The fever develops during the night, or during the day the child loses its playfulness and in a few hours is found to have a high temperature, in most cases not exceeding 103° F. (39.5° C.), but occasionally reaching 104° to 105° F. (40° to 40.8° C.). At the same time the pulse will be full and frequent, beating from 120 to 140 times in the minute very commonly. The rapidly rising temperature and great acceleration of pulse are characteristic, and under favoring conditions should excite suspicions of scarlatina. The face becomes flushed, the eyes bright and injected. There is much thirst, but almost complete anorexia. Nausea and vomiting are so frequent that J. Lewis Smith attaches some diagnostic importance to the symptom. Of 214 patients it was present in 162. Jenner thought that severe vomiting is apt to precede severe throat symptoms. Diarrhœa sometimes occurs, especially in graver cases. The tongue may be only slightly coated; frequently it is covered with a white, creamy fur, but remains red at the edges. Already the little patient complains of sore throat (indeed this may be the first symptom to attract attention), and upon inspection the mucous membrane of the pharynx will be found to be swollen and dry, and of a bright or dusky-red hue, and often spotted with small areas of duskier redness. At this stage no curdy nor diphtheritic deposit will be observed. The nasal mucous membrane sometimes participates in the hyperæmia, and a nasal catarrh is induced. There will now be difficulty in deglutition, and already there may be some enlargement of the submaxillary and cervical glands. There is often headache and also delirium, sometimes of an active kind. As the fever increases in severity the patient becomes dull, listless, and drowsy, and various symptoms of cerebral disorder are common in graver cases. In very many cases, however, all the symptoms will be mild. There may be little fever, no noticeable disturbance of the various functions, not even sore throat. Beyond slight peevishness and irritability the child may not seem to be unwell. In not a few cases there may be no prodromal period at all, the eruption first attracting notice. During the prodromal stage the urine is rather scanty, acid, and high-colored. According to Gee, the urine is diminished in quantity; urea is not necessarily increased; chloride of sodium is diminished, sometimes decidedly, the diminution generally ceasing suddenly on the fourth, fifth, or sixth day; phosphoric acid, at first normal, is notably diminished on the fourth or fifth day, remaining for four days from one-third to one-half the normal quantity, and then returning to the healthy standard; uric acid is greatly diminished on the second and third days, becoming excessive on the fifth day, and then normal. Even at the earliest observation albuminuria may be observed. Böning, who denies a prodromal stage, and always encounters the eruption on the first day simultaneously with the chill, has found blood-corpuscles, renal epithelium, and albumen in the urine from the very start. The respiratory movements quicken in proportion to the rapidity of the pulse. Nearly all cases will begin to show the eruption within twenty-four hours, many within twelve hours, a few during the second day. When the eruption appears later, an abnormal or unusually severe form of the disease often follows.

Stage of Eruption.—The eruption first appears upon the sides of the face, upon the neck and submaxillary region, and on the front of the chest, in the clavicular region, as small, pale-red points, closely aggregated although at first discrete, and very slightly elevated. It rapidly extends over the chest (where it becomes most intense), upper and lower extremities, and attains its full distribution by the end of the second day, acquiring a bright red or scarlet color. It occasionally happens that the eruption begins on other parts than those mentioned, or may never become general. Rarely it spreads more slowly, even fading in some localities before the lower extremities are invaded. It is especially apt to affect the flexures of the joints. In mild cases the spots remain discrete over most of the body, and may resemble a fine "prickly heat," densely arranged and of minute size. At times the eruption consists of dark-red points, surrounding hair-follicles, separated from each other by less intensely red areas (Henoch). In cases of greater intensity it is coalescent almost universally, and presents a continuous brilliant scarlet surface, like the shell of a boiled crab or lobster. The intensity of coloration varies somewhat, even in the same patient, depending much upon the degree of heat; becoming paler when the surface is cooled, more scarlet when this is protected by heavy covering, etc. It is, however, not perfectly smooth, but shows the tiny papules upon the reddened base, and communicates to the hand passed over it a sensation of roughness and of dry and pungent heat. Upon the legs and arms the eruption very often becomes more scattered, assuming the form of separate tiny points; rarely it is distributed over distinct

areas of the trunk and extremities, with intervals of faintly erythematous redness (scarlatina variegata). This form, however, is apt to appear in severe complicated cases. It must be remembered, however, that, unlike measles, scarlet fever affects the face less than other parts. Never very intensely developed over the forehead, temples, or chin, the eruption entirely spares an area around the mouth, including the upper and lower lips and some distance beyond the angles of the mouth, and often extending upward to include the nose. This area contrasts with the surrounding parts by its remarkable pallor. It has been asserted that the cheeks are also spared by the eruption. This is not true. The cheeks do not show the pointed redness of the early eruption elsewhere, but at once assume a scarlet or crimson redness that is deeper than the color induced by fever. The lips are often dry and cracked, and may bleed. The face becomes considerably swollen, especially in the loose tissue about the orbits. The ears are also swollen and of a bright red color. The eruption does not spare the scalp. Upon the backs of the hands and feet the eruption is discrete, and is arranged in groups the size of a lentil, while upon the palmar surfaces of the hands and fingers, and upon the soles of the feet, a bright, diffused redness, with swelling, is seen. At times the eruption will be partial, developing upon the trunk alone, or on the extremities, or in isolated patches about the body. These cases may not be abnormal in other respects. The skin over the joints is especially prone to be affected. The lesions may be more or less disseminated spots, varying from the size of a pin-head to that of the finger-nail, or a half-dollar, or even larger. It has been asserted that the eruption constantly consists of a papulated rash upon a reddened base, even when universally diffused. This is not invariably so, and one may encounter a smooth, uniform redness inappreciable to the touch. Where the eruption is very intense, small hæmorrhagic spots, or petechiæ may appear. When thus occurring, their occasional presence is not of serious importance. In warm weather especially, and in children too warmly covered with bedclothes, the surface, particularly of the neck, chest, and belly, is sometimes plentifully sprinkled with an eruption of sudamina. In some epidemics these are more often observed than in others. It is not impossible that the "miliary fevers" that formerly occasionally prevailed in Europe, were, in reality, forms of scarlatina. Mayr has said that the eruption of scarlet fever often spares the skin of paralyzed limbs; but Kaposi asserts that it may be unusually intense upon these parts. In dark-skinned races the eruption undergoes some modifications, which are greatest in those of full negro blood. In mulattoes and negroes it becomes often exceedingly difficult to distinguish the eruption. Of course the scarlet color is absent, a tinge of red will often struggle through the darkly pigmented skin, especially of the cheeks and abdomen. The true character of the eruption may often be revealed by a finely papular condition, the tiny papules of the size of a pin-point being made apparent by their acuminated summits, which give, against the dark background, a resemblance to a sprinkling of the surface with a fine dust. The hand passed over them can perceive the little asperities. These are closely aggregated. In many cases it is impossible to recognize the eruption, and the diagnosis must rest upon the concomitant symptoms, which will not be peculiarly modified.

While the eruption—which attains its height by the end of forty-eight hours in mild cases, later in severe ones—is developing, the other symptoms become pronounced. The faucial mucous membrane is uniformly redder, or, occasionally, shows numerous red macules; the uvula, tonsils, and buccal mucous membrane are reddened and swollen, and pain in deglutition increases. As the eruption reaches its height, the tongue parts with its coating in patches, exposing areas of intense redness. By the third day it acquires a uniformly brilliant red color, with enlarged papillæ scattered numerously over its general surface, and presents the characteristic "strawberry" or "raspberry" appearance. Exceptionally, this exfoliation of the lingual epithelium does not occur, and the creamy deposit persists. In many mild cases there is slight nasal catarrh, with a thin discharge from the nostrils. A muco-purulent discharge from the nostrils is associated with the throat complications of the graver forms.

During this period the fever continues to increase until the completion of the eruption, or the prodromal temperature remains unchanged. In the type of cases we are considering 105° F. (40.5° C.) is not often exceeded. Should the fever continue to increase after the third day, grave solicitude as to the result will be justifiable. The other symptoms continue with undiminished vigor—digestive disorder, nausea, vomiting, complete anorexia, rarely diarrhœa, persist. The skin burns or itches more or less intensely. Nervous symptoms, restlessness, stupor, headache, delirium, usually diminish, but may continue unabated; or active delirium may occur. Convulsions at this time are very ominous. The sore throat becomes distressing, and the cervical and submaxillary glands enlarge and become painful. Bronchial and pulmonary inflammation only occur as complications. After the fourth or fifth day nearly all of these symptoms cease to increase, and it becomes evident, *cæteris paribus*, that the course of the disease is to be favorable. The eruption, after persisting in full development for a day or two, becomes duller and slowly fades, first in the parts earliest affected, latest from the back of the hands. The color, which at first completely faded, now leaves a yellowish stain when the finger compresses the skin. It is not, however, until after four, five, or six days, that the skin loses its scarlet color. This may last longer. Jenner[23] has known it to persist for from fourteen to sixteen days. The fever slowly declines, until it ceases about the sixth, seventh, or eighth day, or later, and not before the eruption has entirely disappeared. Sometimes, from unknown reasons, it persists for days after all local symptoms have ceased to be active. On the other hand, fever, in some very mild cases, will hardly be noticed, or will endure but a few hours. The throat manifestations, or the supervention of complications, may protract the fever for many days. The sore throat, unlike the other symptoms, often fails to show signs of amelioration after the height of the eruption. The swelling and redness may increase, and white or yellowish curdy deposits form upon the tonsils and uvula, or the posterior wall of the pharynx may be bathed in a thick muco-purulent discharge from the posterior nares. True diphtheritic membrane is not apt to form in these cases, but the neighboring lymphatic glands may become highly inflamed and suppurate. It is probable that renal catarrh and nephritis occur more frequently during this period than is commonly supposed. Frerichs, Reinhardt, Eisenschitz, Böning, Begbie, Newbigging, Holder, and others, consider the renal symptoms as essential in scarlatina. This is, however, not true. Thomas[24] practised microscopic examinations of the urine in twenty-five of eighty patients, and in twenty of these daily. In the prodromal and eruptive stages he found slight albuminuria only rarely and transitorily. Decided alterations in the renal tract were most uncommon. Mild catarrh was more often seen. Only the more severe forms he considered to depend upon a specific scarlatinal influence. Fleischmann,[25] in 472 cases of scarlatina, reported dropsy during the first week in 9 cases. Not enough, certainly, to bear out the sweeping assertions just quoted, but sufficient to direct attention constantly to the condition of the kidneys in scarlatina.

Many cases of mild scarlatina fail to exhibit all the symptoms enumerated. The prodromal stage may be absent, sore throat may be insignificant, or absent throughout. The tongue may never assume the "strawberry" appearance. The fever may be of feeble intensity. Finally, the rash may be faint and not widely distributed. It may be limited to a few reddish or pinkish punctate spots upon the neck or chest; or it may only affect the flanks or the flexures of the joints; or it may be so transitory as to escape observation or to be noted only during a few hours; or, finally, it may fail altogether to appear. On the other hand, sore throat may be the only active evidence of the disease. Cases that have been exposed to the contagion sometimes develop sore throat

only. These may subsequently become dropsical from nephritis, or they may desquamate more or less abundantly, or even communicate scarlet fever to others. An interesting feature is a tendency, often shown by those exposed to contagion, to suffer from a mild attack of pharyngitis after every exposure. Many physicians, nurses, etc., experience this. Finally, the eruption may fail to appear, knowledge that scarlatina was present being acquired through the occurrence of desquamation or dropsy. Cases of this kind have been designated "*scarlatina sine exanthemate.*" They are not so very rare. At other times the eruption is so indeterminate in appearance that, in the absence of accompanying symptoms, it is impossible to speak positively of its character.

Stage of Desquamation.—After the fading of the eruption the patient passes into the stage of desquamation. This is an immediate result of the eruption. Desquamation begins usually upon the neck, and continues for from eight to fourteen days, but not infrequently for four, six, or even eight weeks or more. Usually not earlier than the sixth day of the disease it is noticed upon the neck and face, and quickly extends over the whole surface, and may even occur upon parts not visited by the eruption. Upon the face and neck the scales are mostly fine, but coarser than those following measles. From other parts the epidermis peels in great shreds. On the hands and feet the lamellæ are always large, and sometimes from these members the cuticle is removed in masses resembling a glove or slipper. Desquamation endures longest where the epidermis is thickest, often for weeks; that newly formed exfoliating repeatedly. The hair and nails are sometimes shed after scarlet fever. Desquamation is at times observed in those who have had no eruption, or, at least, one of very circumscribed extent. With the completion of desquamation the disease may be said to have run its course. Great care, however, must be exercised for some weeks to protect the patient from the effects of complications and from the sequelæ to which the disease has made him liable. With the fading of the eruption, the cessation of fever, and the beginning of desquamation, general improvement takes place. The tongue gradually resumes its normal appearance, or for a time becomes again coated; the sore throat diminishes; the various functions are properly performed; appetite and strength return. Desquamation may, however, be sometimes delayed. The local use of oils and ointments during the eruption tends to make the desquamation less free. The occurrence of dropsy sometimes defers the beginning of desquamation, and this may not become abundant until after the dropsy has subsided. Contagion has spread from desquamation beginning in this manner, after isolation has been abandoned as no longer necessary. In rare cases desquamation can hardly be said to occur at all. Even in mild cases, in winter, the patient should not be permitted to leave his bed until the end of the third week, or to leave his chamber until the completion of desquamation. In midsummer it is usually not advisable to insist upon confinement to bed for so long a period. Cases which run the apparently mild course just described are by no means free from danger, as they are often accompanied or followed by local pathological processes which, while they may not be essential symptoms of scarlet fever, are especially prone to affect those suffering from it. Such lesions will be considered among the complications and sequelæ of scarlatina.

Graver Forms.—Every case of scarlatina is dangerous. In those following the type just described the peril arises from processes that are not essential to the disease. Such forms pass, by insensible gradations, into those where life is imperilled by the greater or less intensity of characteristic phenomena. The graver forms of scarlatina may not differ in their initiatory symptoms from those already described. In most cases the severity of the disease is in great measure dependent upon lesions in the throat, while, as a rule, the eruption shows a more general distribution and a more intense coloration. The prodromal symptoms do not differ in kind from those of milder types, but are more severe. Vomiting is more apt to occur, and nervous symptoms to become prominent. Headache, jactitation, and delirium become more marked, or the patient grows petulant, drowsy, and stupid. Convulsions also may occur. Fever attains great intensity at the very outset, reaching 40° to 42° C. (104° to 106° F.), the latter temperature always denoting extreme danger. There is already sore throat, with difficult deglutition and with swelling and deep redness of the faucial mucous membrane, which by the third day, in the less severe cases, shows curdy deposits scattered over the tonsils. These deposits do not involve the mucous membrane, and may generally be detached by a mop or a brush. They are quite like the exudation of ordinary catarrhal pharyngitis. After the third or fourth day, under conditions of constantly increasing fever and general distress, in some cases, diphtheritic exudation begins to show itself over the tonsils and soft palate, and posterior wall of the pharynx. It is an interesting point of difference between primary and scarlatinal diphtheria that the latter never begins to appear before the third or fourth day, after which date it is sufficiently common. Fleischmann reported diphtheria 168 times in 472 observations. The diphtheritic deposit is first developed on the lateral portion of the tonsils, except in those rapidly fatal cases where the whole pharynx seems to be simultaneously involved. The patches are of a whitish or grayish-white color, and involve the mucous membrane sometimes to a considerable depth and superficial extent. At times the diphtheritic membrane rapidly spreads in a continuous sheet over the fauces, extending forward into the buccal cavity and into the posterior nares. In the latter case, a fatal termination is almost inevitable. Heubner [25] asserts that those cases in which the entire mucous membrane, from the root of the tongue to the œsophageal and tracheal orifices, is covered with the membrane, die within twenty-four or forty-eight hours, without exception. Here the membrane is sharply margined against the dusky-red mucous membrane, and within a few hours the slough shows signs of separation and develops a gangrenous odor. In these cases the membrane hardly ever travels down into the trachea. Bretonneau has made a positive assertion that this does not occur. It does so occasionally, however. Lewis Smith reports cases, with necroscopic examination, where diphtheritic membranes extended along the trachea into the bronchial tubes. In the most severe cases, however, the deposit does invade the posterior nares, and the ordinary slight catarrhal discharge is supplanted by an offensive sanio-serous or sanio-purulent discharge from the nostrils, which causes excoriation of the upper lip. At the same time the nares become obstructed, and the little patient is driven to breathe almost entirely through the mouth. In many cases of extreme throat involvement the strength rapidly fails, pallor replaces the prematurely receding eruption, except at certain spots where this may persist as circumscribed patches of dusky redness; the temperature remains stationary or falls, the pulse becomes more and more feeble and rapid, and death ensues within a few hours, as if from blood-poisoning. Death either follows slow spread of gangrene to the soft palate and tongue behind the *sinus pyriformis*, and to the walls of the throat, or occurs through diphtheritic inflammation of the lymph-glands and connective tissue of the neck, or through œdema of the glottis. At other times the clinical appearances during the first week may not be alarming, danger becoming imminent about the beginning of the second week. The fever may remain elevated, the eruption brilliant and intense, until a short while before death. In the rapidly fatal cases the throat and neck may not appear very much swollen. At other times the neck and submaxillary region are greatly swollen, principally from the inflammation of the glands and peri-glandular tissue. These parts become hard and brawny, and from the pressure upon the great veins acquire a livid appearance, which may also be communicated to the face and head. The tonsils and soft palate may be swollen until the throat will appear quite closed. The mucous membrane will be deeply congested, and covered here and there with diphtheritic exudation, and with ulcers caused by the separation of sloughs. The

posterior wall of the pharynx may be bathed in muco-pus. Retro-pharyngeal abscess is sometimes formed, and may precede the fatal termination. Dyspnœa may result from swelling of the fauces caused by inflammatory exudation into the parts, from *œdema glottidis*, or from extension of diphtheria to the larynx and trachea, or it may be a result of the imperfect oxidation of the blood. The term "diphtheritic" is here used in a clinical sense, to designate a condition of coagulation-necrosis in the tissues involved, and has no reference to a pathogenetic relationship with true diphtheria. This necrosis occurs simply as a result of the intensity of the accompanying inflammatory changes. There is no evidence that true diphtheria may not co-exist with scarlatina, but that the commonly observed membranous pharyngitis of scarlatina represents this combination is most improbable. J. Lewis Smith has seen four instances where the diphtheria became dissociated from the scarlatina, and attacked other persons as idiopathic diphtheria. Such observations are exceedingly uncommon. The scarlatinal diphtheritic membrane is, indeed, essentially identical with that of idiopathic diphtheria in structure. The differences are etiological. The diphtheritic poison and the scarlatinal poison, differing in their specific natures, possess in common the power to excite such violent inflammatory changes in the tissues that a coagulation-necrosis results. The diphtheritic membrane of scarlatina, then, is purely scarlatinal in its origin. This view has received solid endorsement. It has been adopted by Henoch. Heubner considers scarlatinal diphtheria to differ from primary diphtheria both clinically and histologically. It begins with a simple catarrhal affection, and, following his observations, changes from catarrhal to diphtheritic inflammation on the fourth day. Koven also thinks that the throat affections of more severe grade are necrosis from direct intensity of the scarlatinal process, and not truly diphtheritic. He observes that while two acute diseases rarely co-exist, of 426 cases of scarlatina 125 had *necrosis faucium*, although at the period of observation there was not a single case of primary diphtheria in Christiania. He further declares that diphtheritic paralysis never occurs after scarlatina, and that while true diphtheria shows the membrane at once, the scarlatinal slough usually appears after several days of increasing angina, and does not extend to the larynx.[27] Henoch has never seen a single case of accommodation paralysis of the eye or of the soft palate, nor of the neck, nor of the extremities, after scarlatinal diphtheria. The inflammation may, often does, extend along the Eustachian tube to the middle ear, and excites changes that give scarlet fever one of its principal terrors, resulting often in more or less complete permanent deafness. These changes will be considered with the complications and sequelæ of scarlatina. In a number of these cases cervical adenitis and periadenitis occur, and prolong the fever beyond the eruptive stage indefinitely, frequently resulting in suppuration. Occasionally the pus burrows deeply among the tissues of the neck, and extensive gangrene may follow. Williams has reported a case of extensive sloughing in the left anterior triangle of the neck, with exposure of vessels, followed by recovery. Other similar cases have been recorded. In most cases where death does not speedily occur after suppuration and evacuation of pus recovery will take place, but the patient may ultimately succumb under blood-poisoning and protracted fever. Occasionally, also, parenchymatous tonsillitis may cause rapid and enormous enlargement of the tonsil, with the formation of pus, a condition of extreme gravity, especially if associated with retro-pharyngeal abscess and œdema of the glottis. In favorable cases the sloughs in the fauces will cease to extend, the œdema and dusky redness will slowly subside, and the diphtheritic ulcers begin to granulate.

In many cases the faucial symptoms here described do not appear, only because life is early destroyed by the intensity of the action of the specific poison upon the blood and tissues. In such malignant cases the patients often die with the rapidity of those who succumb to narcotic poisoning; or a series of convulsions inaugurate the disease and terminate life within an hour or two. At other times brief initiatory symptoms have been followed by intense fever (106°–109° F.), with uncontrollable vomiting, diarrhœa, delirium, rapidly deepening coma, and death, before the appearance of the eruption. Or, again, the disease may begin in the ordinary manner, not suggestive of a severe course, and alarming symptoms may not develop until after several days; or it may be intense from the beginning, with severe and repeated convulsions, vomiting, profound nervous depression, and the appearance of the eruption at the usual time, with steadily increasing gravity of all the symptoms, until, after a few days, death results from convulsions or coma. Finally, the malignant symptoms will appear suddenly in the midst of what has seemed a mild attack of scarlatina. An unusually protracted period of invasion is sometimes the forerunner of malignant scarlet fever, and should always be regarded with apprehension. Cases may at times exhibit at the beginning alarming symptoms. A decided apathy, in which no notice of what is passing is taken, with great apparent depression and even delirium, excites the apprehension of the attendants, yet the pulse and temperature will not show marked variation from the normal. After the second or third day such cases will very often pursue a mild course. A high temperature and very quick pulse may even be added to these symptoms and justly excite alarm, and yet the case may assume a favorable character after the development of the eruption. In such cases as these the probability of the issue in life or death seems to vary from hour to hour. All the symptoms show intensity. The fever, accompanied by more or less severe initiatory symptoms, rapidly increases, the eruption is copious and deeply colored, the pulse beats 130, 140, 160 times, or oftener to the minute, the respiration is proportionally accelerated, the throat duly shows more or less extensively the peculiar alterations. This course may be held throughout the first week, and even longer, without mitigation, the result remaining doubtful all the while.

In malignant scarlet fever the usual course is one of intensified general symptoms. Those of the invasion period are indicative of grave perturbation of the economy. By the time the eruption appears it is already evident that the patient is dangerously ill. He is apathetic, or perhaps extremely restless, remaining in one position not an instant. The skin is hot, dry, and pungent, the temperature very high, the features swollen, the conjunctivæ injected, the fauces reddened and dry, the thirst intense, but water and all ingesta are often vomited as soon as swallowed; the urine is scanty, or even suppressed, from acute renal inflammation. Diarrhœa may be present. The nervous phenomena become intensified. The eruption now appears, and may at first develop regularly, but after a while will become duskier and will not completely fade on pressure. The color tardily returns to the part whence it has been pressed. Coma or convulsions may now carry off the patient in full eruption. Often, however, the eruption will recede from certain parts in whole or partially, or it may become paler universally; or in place of the regular eruption hæmorrhagic exudation will appear. Ecchymoses, from the size of a pin-head to that of the palm, or larger, will replace the usual eruption, which will in great measure disappear. Then livid spots, not fading on pressure, are found, generally upon the flanks and back, but may appear anywhere. According to Mayr, the hæmorrhagic eruption may appear over a large part of the surface in children, but in adults is mostly confined to the neck, upper part of the chest, the back, and about the joints of the upper and lower extremities. This hæmorrhagic variety is the most formidable form of scarlet fever, and is probably always fatal. Hæmorrhages from mucous surfaces are exceedingly uncommon. Mayr has described a scarlatinal dissolution of the blood, in the gravest form of which death occurs in from twelve hours to five days. "Extreme muscular depression, with slight headache and a remarkably rapid pulse, are present from the very commencement. . . The patient lies on his back with his eyes half open, but in an unconscious state. . . . Quivering movements of the

muscles of the face and of the fingers are also commonly observed in these cases, and in children general convulsions often occur. The pupils are moderately dilated; the lips and tongue are dry, the latter being usually of a bright-red color. As the disease goes on, mucous râles are heard in the large bronchial tubes; the abdomen becomes distended, but there is seldom any enlargement of the spleen; the urine becomes scanty and of a dark-red color; the pulse continually increases in frequency, reaching as many as 200 beats a minute; the features become shrunken and the extremities cold." Death speedily follows. This form resembles the so-called typhoid scarlatina, in which drowsiness, stupor, delirium, and subsultus precede the fatal issue. The life-destroying symptoms are often connected with impairment of the heart's action, attributable to crippling of the vagus, when death occurs from heart-paralysis, without widespread molecular disintegration. This failure is shown by increasing weakness, frequency and inequality of the pulse, with quickened and shallow breathing, and coldness of the hands and feet. Allbut has classified the modes of death in scarlet fever as follows: 1, Hyperpyrexia (this Jenner denies positively); 2, specific blood-poisoning; 3, special malignity of the case; 4, asthenia. In the rather uncommon event of recovery from any of the most severe forms of scarlet fever, the progress is slow, the essential symptoms, complications, and sequelæ proving all very obstinate. In those cases where extensive diphtheritic exudation precedes a rapidly fatal course, the eruption undergoes many modifications, the integument remaining pale except for some few splotches about the joints, at other times showing only a few dark-red patches irregularly distributed, and again entirely disappearing before death. At other times the eruption persists in full efflorescence.

Complications. — *Nephritis.* — Derangements of the kidneys are the most important complications of scarlet fever. Indeed, a number of recent writers assert that these organs are always affected in this disorder. Among these may be mentioned Frerichs, Reinhardt, Begbie, Newbigging, Holder, Böning, and Stevenson Thompson. Steiner states that evidences of kidney disorder are always present in those who die of scarlet fever. Thomas' clinical observations do not bear out this statement, and Friedländer, who examined the bodies of two hundred and twenty-nine persons dead of scarlatina, found kidney disorder in less than one-half. Though renal inflammation is not shown as yet to be a constant accompaniment of scarlet fever, it occurs much more often than is commonly supposed. Renal catarrh, which Eisenschitz declares to be as much a feature of scarlet fever as bronchial catarrh is of measles, is indeed an extremely common complication. It usually escapes detection from the general neglect to duly examine the urine. Thomas, in denying that this catarrh is at all constant, shows that it also occurs in measles, croupous pneumonia, etc., and is often only an expression of the febrile condition. Yet the catarrh is relatively so common in scarlatina that he cannot avoid concluding that the specific influence of the disease is often concerned in its production In many cases, from the very beginning, cylinder-like masses of renal epithelium may be detected. In milder cases the urine will contain mucous casts with increased quantity of mucus, but no albumen. In more severe cases the urinary sediment will contain hyaline masses with epithelium and epithelial *débris*, and red and white blood-corpuscles. Slight albuminuria will also be present. This catarrh is usually insignificant, and but rarely serves as the starting-point for the graver and characteristic forms of nephritis scarlatinosa, though doubtless many milder forms of nephritis and dropsy originate in it. Thomas concluded, however, that the cases of scarlatinal nephritis not developing from preceding catarrh, but arising suddenly, usually end fatally. Scarlatinal nephritis varies greatly in the relative frequency of its occurrence, involving from five to seventy per cent. of cases in different epidemics. In the Children's Hospital, Hillier noted its occurrence in about half of the cases. Dickinson [28] considered this rather below than above the average. Fleischmann [29] noted 95 cases of Bright's disease in 472 observations. During 1861 every third child with scarlatina had dropsy, while in 1862 it affected only one case in ten. Thomas asserts that renal alterations develop in about one-half of all cases of scarlet fever. It has been shown that there are those who assert that the renal alterations are constant. On the other hand, Jaccoud [30] declares that for fifteen years he has never had a case of nephritis among his scarlet-fever patients, a result that he attributes to his treatment. Albuminuria may appear at any time during the attack of scarlatina, though its most common occurrence is during the second and third weeks. Dropsy should not be taken as marking the beginning of the nephritis, the signs of which may be present in the urine sometimes for days before this occurs. In Fleischmann's cases dropsy occurred 9 times during the first week, 30 times during the second week, 23 times during the third week, 20 times during the fourth week, and 5 times after the fourth week. Of 60 cases at the Children's Hospital, 42 began between the end of the first week and the end of the fourth week; 5 became dropsical during the first week.

Nephritis during the first week of scarlatina often escapes detection from the blending of its symptoms with those of the essential disease, and from the attendants' neglect to examine the urine. Dropsy will, of course, attract attention, but this does not often occur so early, and may be confounded with the œdema from the exanthem. Rarely, the fatal issue of what was, apparently, malignant scarlet fever, may really have resulted from uræmic poisoning due to a fulminating nephritis. The symptoms may be identical. Fever, vomiting, headache, delirium, amblyopia, coma, convulsions, may have been present. The convulsions are often very irregular. They may be general, partial, or unilateral, tonic or clonic. The patient may have them in rapid succession, or may pass into a *status epilepticus* from which death alone will release him. The urine will be completely or partially suppressed. If secreted it will be of high specific gravity (1.020 to 1.040), dark and smoky in appearance, loaded with albumen, and forming an abundant sediment of hyaline, granular, epithelial, and blood tube-casts, with renal epithelium and white and red blood-corpuscles in greater or less quantity. If the kidneys become implicated toward the end of the first week, the symptoms may delay the course of what may otherwise appear to be an ordinary case of scarlet fever. Microscopical research will often betray the onset of the changes in advance of chemical analysis; casts of the renal tubules will be observed, with epithelial deposits and detritus, before albuminuria is established. This will shortly appear, and in severe cases the nephritic symptoms will obscure those of the scarlatina. There will be no constant relation between the amount of albumen, the tube-casts, and the general detritus, one variety of sedimentary matter being at one time copious, at another scanty. At this time vomiting may appear with returning headache, the appetite will again fail, and pain in the loins may become annoying; the patient may again become dejected and feeble, and his fever may cease to diminish—may even exceed its original intensity. At other times no apparent influence will be exerted upon the scarlatina, which will follow its usually mild course until dropsy and albuminuria reveal the state of the kidneys. When the renal disorder develops after defervescence, during the second, third, or fourth week, or later, the same series of symptoms may be observed, their severity being in direct ratio with the earliness of their occurrence. Cases developing after the fourth week may be expected to pursue a favorable course. Although it has been asserted that the renal disorder may arise several months after a scarlatinal attack, a patient will almost certainly escape it if he pass the sixth week in safety. The symptoms in cases arising during these weeks are not always gradually developed, and some of the most disastrous results of the disease may be encountered during the second, third, or fourth week, in children apparently convalescing from scarlatina, and often in full desquamation, who, after indisposition for a few hours, with nausea, headache, con-

fusion of ideas or stupor, with return of fever, rapidly pass into coma or convulsions, ending after a short interval in death, before dropsy has developed, but after partial or complete suppression of urine. Scarlatinal nephritis has usually a mild and favorable course. Dropsy is usually the first symptom observed, first appearing in the face and sometimes remaining confined to this locality; at other times becoming general speedily, and giving an appearance of plumpness, but with a wax-like translucency of skin. The face, upper and lower extremities, body-wall, and prepuce, may thus become dropsical. The serous cavities are also implicated, and more or less effusion into the pericardial, pleural, peritoneal, scrotal, and intracranial cavities occurs. Œdema of the lungs and of the glottis may imperil life. Desquamation is often completely arrested upon the supervention of dropsy. The temperature is more commonly but little above the normal (38.3° to 39° C. [101° to 103° F.]). The pulse, sometimes feeble and accelerated, will often become remarkably slow and intermittent, and so remain throughout the attack. The child will grow dull and listless, and extremely feeble. Pain in the belly and in the back may at times prove very distressing, or, again, it may be absent. The tongue, having lost the strawberry aspect of the eruptive stage, will become pale, flabby, and coated. The appetite will fail, and the bowels become sluggish. The urine will rapidly diminish in quantity and may deposit urates abundantly, or may present a smoky and oily appearance, due to the abundant presence of epithelial cells, white and red blood-corpuscles, and tube-casts. The total amount may now be reduced to a few ounces. The blood-corpuscles often form a thick red layer at the bottom of the test-tube. This free admixture of blood may amount to pronounced hæmaturia. Such hæmaturia is generally post-scarlatinal, and, according to Schütz, occurs most frequently during the third or fourth week. Of itself it adds but little to the gravity of the case. The patient often feels fairly well, and may eat and sleep with comfort. While the pallor and œdema may be very decided, the temperature and pulse may vary but little from the normal, or may show the variations of ordinary nephritis. With the gradual improvement of the general symptoms the hæmaturia disappears. Heubner has reported a case of nephritis after scarlatina in which hæmoglobinuria was present. The urine was brownish-black; no blood-corpuscles were found. Death resulted from asthenia on the fifth day after both albumen and hæmoglobin had disappeared from the urine.

The amount of albumen in the urine in scarlatinal nephritis is usually very great. The urinary sediment is abundant, and is largely composed of tube-casts, the hyaline character predominating; finely and coarsely granular, epithelial, and blood casts are, however, numerous. Later coarse fatty granules stud the casts plentifully. These casts are often almost diffluent, and differ strikingly from the firm and sharply outlined ones of more chronic nephritis. Crystalline deposits are scanty, and are mostly of uric acid and urates; on the other hand, the amorphous urates are often very abundant. The degree of albuminuria present is of less importance than the total quantity of urine secreted, rapid and pronounced diminution of this indicating the accumulation of nitrogenous waste in the blood, and consequently the danger of uræmia. According to Glax, a lessening of the proportion of urine secreted to the fluid ingested (2 : 3), not infrequently foreshadows the approach of uræmic symptoms, even though the urine contain no albumen. Whether the temperature remain normal throughout the attack, or whether, after an initial chill, it become elevated, and all the symptoms of acute nephritis develop, complete recovery may reasonably be expected if the patient pass safely through the earlier phases of the disorder. But although nephritis may be mild, the dropsy lasting only a few days, and, perhaps, being limited to slight puffiness about the eyes, the disorder does not usually entirely subside in less than a month. It may endure as long as three, four, or even five months; and there is good reason to believe that chronic nephritis in young people may, in rare instances, have had its beginning in antecedent scarlatinal inflammation of the kidneys. Such a result is, however, exceedingly uncommon.

The dropsy indicates the degree of renal derangement, except in the most acute cases, and sometimes attains enormous proportions. As the urine increases in quantity the albuminuria proportionately diminishes, and the dropsy disappears. The skin, which until now has been dry and inactive, becomes softer, more elastic, and resumes its proper functions. The appetite improves, the spirits, strength, and mental activity return, and good health becomes gradually restored. Just as the microscope reveals the earliest evidence of renal derangement, so does it continue to expose the results of pathological action after chemical tests fail to do so. Tube-casts continue to appear in the urinary sediment, sometimes for weeks after the cessation of albuminuria, the blood-casts, epithelial, coarsely granular, and fatty casts gradually giving place to finely granular, hyaline, and mucous ones, which, in turn, finally disappear. When the disorder terminates fatally, the symptoms will be those of acute nephritis; suppression of urine may be followed by cerebral disturbance, headache of violent character, during which blindness may occur, with or without dilatation of the pupil, vomiting, and convulsions, partial or general, coma, and sometimes paralysis; or the fatal termination may be slowly reached through constantly increasing asthenia; or, what is more frequent, complications may arise which cannot always be definitely ascribed to the nephritis or to the scarlatina itself. Such are inflammations of the pleuræ, of the pericardium and endocardium, the peritoneum, the cerebral meninges, etc. Pneumonia, acute articular rheumatism, or enteritis, may also hasten the fatal issue.

Cases are occasionally observed in which dropsy follows scarlatina, but without albuminuria. Indeed, a tendency toward non-albuminuric dropsy after scarlatina has been associated with certain epidemics. Scarlatinal dropsy without albuminuria has been observed by Guersaut, Rilliet and Barthez, Noirot, Bouchut, Löschner, Duckworth, and others. Quincke [31] tries to explain such cases of non-albuminuric dropsy as not depending upon nephritis, but as a consequence of the scarlatinal irritation exerting some peculiar influence upon the connective tissue. Cases occur probably in the experience of most practitioners. One should be cautious, however, in deciding against a nephritic origin of these dropsies, except where they can be definitely attributed to anæmia and debility. Henoch [32] has asserted that nephritis may occur without albuminuria up to the time of death. He reports a case in which anasarca was present for three weeks after scarlatina, without tube-casts or albuminuria, until convulsions occurred, death resulting from œdema of the lungs. The necropsy revealed the presence of acute nephritis. He also reports the case of a child, dead on the thirteenth day, of malignant scarlet fever, in whom repeated tests during life had not shown albuminuria, and yet whose kidneys showed indubitable evidence of hæmorrhagic nephritis. Steiner has seen nephritis without dropsy, but never dropsy without nephritis, after scarlatina. It is altogether probable, however, that in many cases the dropsy following scarlatina without albuminuria is secondary to concomitant anæmia. This is the view adopted by Henoch. Whatever be their explanation, such cases usually run no remarkable course. The general health is not much reduced. The urine is in normal amount, the various functions are fairly performed. With the disappearance of dropsy convalescence is established.

Scarlatinal nephritis is not associated with any especial phase or type of scarlatina. It is as frequent after mild as after severe attacks; indeed, it is possible that the care exercised over those who have grave attacks of the fever, in proper nursing and surroundings, may furnish a safeguard against renal complications. At all events, there is a widespread belief that the milder cases are more apt to be followed by nephritis and dropsy. Violent nephritis may certainly follow a scarlatina so mild as to have escaped observation. Individual predisposition and epidemic type are probably the most important etiological

factors, though at present enough is not known to justify dogmatic statement. The nephritis and dropsy may occur without antecedent symptoms of scarlatina. Instances of this are not uncommon. Several members of a family or of a school or asylum in which scarlatina has been known to prevail, may exhibit dropsy and albuminuria characteristic of scarlatina, without having manifested any other symptom of the disease. Such cases pursue an ordinary course generally, but at times develop a severity altogether unexpected.

INFLAMMATION OF THE GLANDS AND CONNECTIVE TISSUE OF THE NECK.—Although Barthez and Rilliet, and others have observed cases of scarlatina in which there was no angina, in one form or another it is nearly always present. More or less hyperplasia of the neighboring lymphatic glands also constitutes part of the ordinary phenomena of scarlatina. It has already been shown that the inflammation sometimes leads to suppuration and even gangrene of the glandular and peri-glandular structures. This especially occurs in scrofulous and rachitic children, but is probably a result of septic absorption. The active symptoms become prolonged beyond those of simple scarlatina into the second, third, or fourth week, and even later, and merit some especial notice. They may not develop until as late as the third or fourth week, thus constituting true sequelæ rather than complications. Usually the fever continues after the subsidence of the eruption, the pain and stiffness of the neck increase, and deglutition continues painful and difficult, or even almost impossible. The mouth may be held open and saliva constantly dribble from it. The neck becomes hard, brawny, and swollen; the integument tense, smooth, and shining. The outline of the neck sometimes stands in line with that of the head and underjaw, and it becomes impossible to distinguish the enlarged glands in the mass of inflammatory exudation. The patient is unable to find repose, or to swallow food or fluids, unless in small quantities and with great pain. Rest is broken and unrefreshing. Suppuration reveals itself by dark-red, livid spots which soon fluctuate; or, it may be deep-seated and difficult to detect, or may point and discharge internally. The parotid gland and peri-glandular tissue often become involved. At times more or less widespread necrosis may lay bare important muscles, vessels, and nerves, and involve large areas of tissue. These diphtheritic and gangrenous inflammations may give rise to phlebitis or arteritis with thrombosis, and embolism with metastatic inflammation. Compression of the larynx, of the trachea, or of the jugular veins may also result. At times pus may burrow into the deeper cervical structures. Hæmorrhage may also occur from exposed vessels. Baader [33] reported two cases of death from hæmorrhage thus occurring. The extent of these phlegmonous inflammations of the neck varies greatly. In most cases, after the evacuation of pus, recovery follows, though slowly. In more severe cases death may result from exhaustion or from blood-poisoning. In healing, the scars may be insignificant, or, where granulation involves a large surface and is protracted, the resulting cicatrix may occasion deformity by its contraction. Retro-pharyngeal abscess, which has already been described, is not common. Schmitz, in the Child's Hospital, in St. Petersburg, did not observe it once in 450 cases of scarlatina. Cases, however, have been reported. Bokai reported it as occurring 7 times in 664 cases. Of these two died. Lewandowsky [34] reported two cases, both resulting in recovery.

DISORDERS OF THE AUDITORY APPARATUS.—These are very important complications of scarlatina. Probably most cases of deafness acquired in early life are results of scarlatina. Of 85 cases of affection of the middle ear following this disorder, 18 had lost the sense of hearing in one or both ears, and 3 were deaf-mutes.[35] Milder degrees of middle-ear inflammation arise by extension from the throat, and are simply catarrhal; but the severer forms are preceded by croupous-diphtheritic inflammation of the fauces. The milder form of otitis media will cause the patient some earache, of which, if he is old enough, he will bitterly complain. Infants will indicate their sufferings by cries, by raising their hands to the ears, by rolling the head toward the affected side. If the Eustachian canal remain pervious, all inflammatory exudation may escape, and no symptoms, other than those mentioned, and slight and transitory deafness, may occur. This latter symptom may result from the pressure of an enlarged parotid gland upon the external auditory canal. But in the severer forms the pain may be excruciating, deafness more or less complete, and fever high. The Eustachian canal becomes occluded from inflammatory swelling, and exudation accumulates in the cavity of the tympanum. Headache may be violent. The drum membrane will be bulged outward from internal pressure, and will be reddened and swollen. The pent-up fluid, unless released by puncture of the drum membrane, finds an exit for itself by perforation. Extreme pain is often produced by pressure upon the tragus and over the mastoid process. Rarely, delirium may be followed by signs of meningitis from extension of the inflammation from the middle ear to the *dura mater*, along the course of the middle meningeal artery. In mild cases the inflammation will subside, with or without perforation of the drum, and hearing may be perfectly restored. In severer cases, timely tapping of this membrane may yet preserve the sense of hearing, but, unfortunately, it but too often happens that the ossicles of the ear, and the tympanic membrane are destroyed; the bony walls, even of the middle ear, become carious, and irreparable damage is done. The severer inflammations involve a croupous diphtheritic process that often entails wholesale destruction. According to Green, disease of the labyrinth, involving absolute deafness, may occur within a day or two. In such cases the watch held to the skull, the ear or between the teeth, may not be heard. Green [36] thinks that when loud "clashing," "ringing of small bells," or "musical notes," are heard during scarlet fever or cerebro-spinal meningitis, these are apt to be immediate premonitions of labyrinthine disease; whereas, the subjective sounds always accompanying acute purulent inflammation of the tympanum are described as "hissing," "singing," "buzzing," or "throbbing." He also suspects that the fluid secreted in immense quantity—a clear, limpid serum—differing from the wine-yellow serum of tympanic inflammation, may be labyrinthine peri- and endo-lymph. Pus may form in the mastoid cells. These changes may occur either as complications or as sequelæ. Caries sometimes appears quite early, and the chronic otorrhœa thus set up may last for years, occasioning widespread disorder of both soft parts and bone.[37] Fatal hæmorrhage from the ear may occur after scarlatina, from exposure of vessels from the diphtheritic processes.[38]

Chronic posterior nasal catarrh, and necrosis of the bones of the nasal cavity, constituting various degrees of ozæna, sometimes follow the extension of the pharyngeal inflammation to the naso-pharynx. The eye may likewise be implicated in scarlet fever. Conjunctivitis may develop as a complication, or diphtheritic inflammation may extend along the lachrymal canal and involve the conjunctivæ. It may produce keratomalachia, and even destruction of the eyeball. Retinitis after scarlatinal nephritis has been observed by Schröter. Its course is favorable. Temporary blindness may be due to uræmia. Acute amaurosis after scarlatinal nephritis has been noted.[39] Transitory blindness, lasting from twenty to sixty hours, has been observed by Ebert,[40] Henoch,[41] Tolmachew.[42] In a case of Förster's it endured eighteen days.

INFLAMMATION OF JOINTS.—Not very infrequently inflammation of the synovial membrane of the joints appears as a complication or as a sequel of scarlet fever. The usual date of its occurrence is during the second week or later. It is often only indicated by pain without swelling, and may be limited to a single joint. In other cases a number of joints are involved, usually the ankles and wrists, knees and elbows. The hip-joints may be affected, and also the smaller joints of the extremities. The inflammation may betray all the features of acute rheumatism—the fugitive character of the inflammation, the metastases, the sweating, the fever, even the tendency to implicate

the other serous surfaces, the pleuræ, the endo- and pericardium, and the meninges. Mahomed's[43] studies showed that, as the urine increases in quantity from the seventh to the fourteenth day, it loses its deposit of lithates, and often its albumen (if this has been present). It is highly acid, and uric acid is abundantly thrown down by the nitric-acid floating test. It was at this period that he found the rheumatism most apt to occur. This rheumatism seems identical with ordinary acute rheumatism, but follows a less protracted course. Cheadle[44] quotes fifteen cases from West, in which endo- or pericarditis, or both, supervened upon scarlatina. These did not occur during the acute stage, but during desquamation. He, however, considered them rather the result of uræmia and nephritis than of rheumatism. Henoch[45] relates two cases in which acute arthritis appeared during the first week of scarlatina, followed by severe chorea and loud mitral murmur. As to the cardiac symptoms, Cheadle concludes that they occur in scarlatina as results both of scarlatina and of nephritis. He also thought that "scarlatina would appear to have a special influence in causing dilatation and hypertrophy without accompanying valvular disease." Endocarditis, which rarely arises, may be very insidious, and may even pass undetected if not looked for. Probably not a few old valvular affections have originated in attacks of scarlet fever. Acute pleuritis or pericarditis may accompany joint inflammation, or may occur independently. In severe cases they may result in purulent exudation and ultimately terminate fatally. Sometimes the serous inflammations are pyæmic. Endocarditis ulcerosa may begin in this manner. Numerous writers have seen purulent arthritis as a sequel of scarlatina. It commonly occurs during the second or third week, and in most instances is mono-articular. Pyæmic arthritis usually results in suppuration, erosion, and destruction of the cartilage of the joint. According to Spender,[46] the wrist-joint is most often attacked, next in frequency the knee and hip. Recovery may take place, but usually death follows the discharge of pus and the formation of fistulous openings, from exhaustion, or from the further progress of the pyæmia. The approach of these complications, which are fortunately rare, may be recognized through the thermometer. Peritonitis occurs most rarely, and is usually purulent.

In the most severe and malignant cases of scarlatina the heart-muscle undergoes, first, cloudy swelling, and later, fatty degeneration, especially on the right side. This is the occasion of death from heart failure in many malignant cases. Inflammation of the respiratory tract is decidedly uncommon in milder scarlatina Bronchial catarrh is apt to complicate serious cases. Pneumonia is seen sometimes as a secondary complication following nephritis, diphtheria, etc. Disorders of the intestines are also uncommon. Diarrhœa, when present, is usually associated with severer forms. Diphtheritic enteritis was the most frequent sequel in the cases observed by Fleischmann. Henoch has seen bed-sores complicate scarlatina.

SEQUELÆ.—The affections that constitute true sequelæ usually are disorders that persist after scarlet fever has completed its course, having begun as complications. Thus are encountered chronic buccal, pharyngeal, nasal, and aural inflammations, nephritis (which, as a rule, ultimately entirely disappears), or inflammation of the various serous membranes. In some cases, marked by severe eclamptic seizures, there results contraction of different groups of muscles, giving rise to permanent deformity. Mania has been known to follow scarlatina.[47] Gangrene, apart from that resulting from diphtheria of the throat, is infrequent. Noma has been observed by a number of writers (Barthez and Rilliet, Heyfelder, Böning, and others), but it is notably less common than after measles. Necrosis of the nasal cartilage was observed by Henoch during convalescence.

CONCURRENCE WITH OTHER SPECIFIC AFFECTIONS.—Scarlet fever may be complicated by, or may complicate, other acute exanthemata, not to the extent, however, that many writers believe. Mayr and Hebra, indeed, taught that scarlatina never coexists with measles or small-pox. This question is involved in much obscurity. Scarlatina may be simulated by a variety of affections that may in fact co-exist with the exanthemata, by various erythematous eruptions, by the roseola that often precedes and accompanies the eruption of small-pox, by certain anomalous forms of measles, and by various medicinal rashes —those caused by belladonna, copaiba, chloral, and especially cinchona and its preparations. These considerations and faulty methods of observation and recording, lead to the rejection of much of the evidence adduced in favor of these coexistences. After all faulty observations are thrown out, however, there still remains strong proof that scarlet fever may coexist with other exanthems. It will be everywhere admitted that one exanthem may follow close upon the heel of another. Prior[48] noted a case in which scarlatina developed on November 18th, varicella on December 2d, and measles on December 13th. When the two exanthems develop simultaneously, there will often remain much doubt, in the absence of evidence of the double exposure of the unprotected individual and of his subsequent double protection. Where one precedes the other by a few days, the difficulties are not so great. Scarlet fever has been observed as complicating, or complicated by, other exanthemata by Steiner,[49] Monti,[50] Thomas,[51] Fleischmann,[52] Fabore,[53] Stillen,[54] Zechmeister,[55] Backer,[56] Dornig,[57] Lewis Smith,[58] Murchison,[59] and many others. The combinations and the order of occurrence have been noted as follows, viz.:

Scarlatina and measles.
Measles and scarlatina.
Scarlatina and small-pox.
Small-pox and scarlatina.
Scarlatina and vaccinia.
Scarlatina and varicella.
Varicella and scarlatina.
Scarlatina and typhoid fever.

Concurrence of scarlatina and Rötheln has not been reported. A probable source of fallacy is the scarlatiniform rash that is often observed in small-pox, and occasionally in typhoid fever; indeed, Simon asserts that Fleischmann has even made this very error. The possibility of these rashes should always be held in mind when questions of concurrence are under consideration. When scarlet fever develops after small-pox the eruption involves the parts of the skin left free by the lesions of small-pox, more especially about the chest and abdomen. When the two exanthems appear simultaneously, their course is shortened; "the second mitigates the first and becomes shortened itself," excepting, according to Fleischmann, when severe small-pox occurs in connection with scarlatina, when death usually results. The same author asserts that if scarlatina appear at the period of maturation of small-pox, the latter, in mild cases, is shortened and mitigated. When scarlatina complicates measles, the latter is shortened, but the scarlatina thus occurring may be mild or severe. Barthez and Rilliet noted that in scarlatina-measles, when the former malady predominates, bronchitis is more marked; but when measles is most severe, faucial angina is worse. All of these statements lack such evidence as would entitle them to unqualified acceptation. Very often neither disease is well developed, and the true condition may be very difficult of recognition. In America these concurrences are more uncommon than they seem to be abroad.

Whooping-cough has been known to complicate scarlatina, and a number of non-specific affections may occur simultaneously with it. These coincidences are purely accidental and present no peculiar interest. Biart[60] has reported psoriasis as following scarlatina. Barthez and Rilliet assert that tuberculous children very rarely have scarlatina. Some chronic affections partially or entirely disappear during an attack of scarlatina. Among these may be especially mentioned certain cutaneous affections, eczema, psoriasis, etc., but they usually reappear upon the establishment of convalescence.

SURGICAL SCARLATINA.—Sir James Paget, in 1864, and again in 1875,[61] declared that patients who have undergone surgical operations are peculiarly susceptible to the

action of the scarlet-fever poison. This question has attracted a great deal of attention. In France, Trelat was the first to accept this view, though scarlatinoid rashes had been observed by Civiale, Germain Sée, Tremblay, and others. Similar rashes were reported by Hutchinson. Hilton, Bryant, Lee, Moore, Stirling, and others. They had generally been considered as of septicæmic origin. In 1879 Paley and Goodhart[62] and House[63] reported observations of endemics of scarlatina in the Evelina Hospital for Sick Children and in Guy's Hospital. The first-named authors based their report upon twenty-five cases of scarlatina occurring in surgical patients. Of these nineteen were known to have been exposed to scarlatina, and all the rest, save one, were known to have had possible sources of infection. House's paper was based upon four cases of surgical scarlatina. The epidemic tendencies ceased upon the establishment of isolation, and one cannot doubt their scarlatinal origin. These writers were careful not to assert that *all* such red rashes should be attributed to scarlatina, or that there is *not* "such a thing as a rose rash in a typical case of septicæmia;" but they believe that when occurring in groups they may nearly always rightly be attributed to scarlatina. Riedinger and Howard Marsh also agreed that there exists in wounded persons a predisposition to scarlatina. While Holmes coincided with these views, he, however, declared that many cases of "surgical scarlet fever" are really due to pyæmia and other causes. Most recent writers incline to the opinion that these eruptions are due to true scarlatina. When any epidemic tendency is shown, everyone will agree with such conclusions. This cannot be granted of rashes occurring in isolated cases. Of 25 cases reported in Paley and Goodhart's paper, scarlet fever attacked 17 after operations; 7 were without any wound whatever, and 1 had only an old sinus. In many of the cases reported by other writers there was no open wound. These reporters, unfortunately, most rarely note whether their patients had ever previously had scarlatina. Most children, when first exposed to the contagion of this disease, become infected. Is it remarkable that they are unable to withstand it when it attacks them, weakened by injury or surgical operation? Apart from epidemic influences, it is probable that scarlatiniform eruptions in the wounded may justly, in a large proportion of cases, occur quite independently of scarlatina. Rashes of septicæmic origin are well known to occur. Various fugitive eruptions often result from emotional and nervous irritations, or from the ingestion of certain articles of food or medicines. It must be admitted that scarlatiniform septicæmic rashes are uncommon. But there is excellent evidence that they occur.[64] Attempts have been made to establish a differential diagnosis for the surgical scarlatiniform rash. Cheadle,[65] for example, claimed that it has specific characters in not often being universal, and in being confined to the body and parts covered by the clothing; that it rarely lasts twenty-four hours, and that it never desquamates. He also asserted that there is no tonsillar swelling, nor glandular enlargement, nor the peculiar "strawberry tongue." Such points of differentiation do not appear to be well founded. Scarlatiniform eruptions also occasionally follow the ingestion of certain drugs. They may be evoked by belladonna, copaiba, opium, chloral, mercury, and other drugs, but, above all, by cinchona bark and its derivatives. These eruptions are much more common than is generally supposed. The quinine eruptions are only beginning to receive due attention. The drug is frequently given to those who have been injured or submitted to surgical operations, and beyond question eruptions evoked by it are often attributed to other causes. A number of eruptive forms are observed, but the one of especial moment is the scarlatiniform rash. At the onset it often cannot be distinguished from scarlatina. Beginning with high fever, and often with sore throat, the eruption appears upon the face, chest, and neck, and within twenty-four hours the entire surface may present a bright scarlet aspect. At the end of this period the resemblance may be made perfect by the "strawberry tongue." Up to this point the diagnosis may be impossible. Rarely it remains so throughout the attack, especially when the ingestion of the cinchona preparation is continued. Usually, however, after thirty-six or forty-eight hours the type of normal scarlatina is departed from. The fever rapidly decreases, the angina disappears, and the rash either fades or acquires features unlike those of true scarlatina. It becomes duller, more papular, and often tends to form miliary vesicles. Eventually it may resemble ordinary "prickly heat." Sometimes, however, the scarlatinal features are preserved throughout. In either case a copious desquamation is sure to follow. This is usually lamellar. Even albuminuria has been known to add to the embarrassment of the diagnostician. These medicinal and septicæmic rashes occur in isolated instances, and may at times baffle the keenest diagnostic powers. We may conclude that unprotected persons who have suffered injury, or who have undergone surgical operations, are rather more liable to scarlatina than the unprotected healthy. Scarlet fever is more apt than the other exanthemata to attack such persons, because its symptoms vary within such wide limits that it often escapes the attention of those who readily detect other infectious disorders and provide against them. When an epidemic tendency of the symptoms we have been considering is shown to prevail, it may be confidently concluded that true scarlatina is present. Septicæmia is occasionally accompanied by a scarlatiniform rash which does not depend upon the scarlatinal poison. These rashes are often attributed to scarlatina.

Scarlatina Puerperalis.—While pregnant women seem to enjoy a remarkable immunity from the specific eruptive fevers, it is well known that during the *puerperium* they are especially subject to them after exposure, and that the disease is then apt to pursue a grave and often fatal course. Not only scarlatina, but measles and small-pox may affect the lying-in woman with such malignity that the symptoms may not acquire the features of the maladies to which they belong, but become indistinguishable from those of malignant septicæmia. Scarlatina is especially liable to attack the lying-in woman. It may assume the virulence referred to, or it may pursue a course in which it is difficult to determine whether its symptoms are septic or really scarlatinal, or, finally, it may appear with typical and unmistakable features. Not a few writers have thought that the scarlatinal virus may produce in the puerperal woman septicæmia, pure and simple. This view is maintained by Playfair, Braxton Hicks, Leishman, and others. They assert that in these women, after exposure to the specific contagium, symptoms of acute blood-poisoning may be developed, and not those of scarlatina. On the other hand, just as in septic conditions, independent of puerperal causes, an erythematous rash and other scarlatinal symptoms may be observed in which true scarlatina has no part, so must one guard against assigning to scarlatina every scarlatiniform rash occurring in obstetrical cases. It may be septic in origin, or it may be a medicinal eruption. When a septic, or medicinal, or other form of erythema can be excluded, and when exposure to scarlatinal influence is followed by any degree of the symptoms we are considering, are we in atypical cases to look upon the results of the infection as distinctly scarlatinal? More recent writers regard the scarlatinal nature of the disorder as preserved, and as capable of further dissemination. It has not been determined to what extent women who have already had scarlatina preserve an immunity from further attacks during their lying-in period. It would appear that the intensified predisposition of the childbed carries with it an increased liability to second or third attacks. Busey[66] has related a case in which the patient had already had scarlet fever. Other such cases are upon record.[67]

In all probability the scarlet-fever contagium evokes scarlet fever, and not septic disorder, in the puerperal woman, whose systemic condition affords peculiar susceptibility to its influence, and predisposes her to a virulence of its activity that often leads to disastrous results. The less remote the date of delivery, the graver the course of the malady is apt to be. If the symptoms do not appear before the seventh day, their development is no

longer to be feared. Olshausen[68] collected from the literature 141 cases, of which the scarlatina attacked, during pregnancy, 7; in 8 it immediately followed delivery; in 62 it occurred on the first and second days; in 27 on the third day; in 22 after the third day. After the fifth day none was attacked. While the puerperal woman shows intense susceptibility to scarlatina, the pregnant woman enjoys a marked immunity from it. Olshausen thinks, however, that the period of incubation may last for months during pregnancy, but only a few days during childbed. This opinion he rests upon no solid basis. Primiparæ are more often attacked than multiparæ. The mortality in puerperal scarlatina is high. In the series just alluded to it was forty-eight per cent. (3 cases during pregnancy and 64 in childbed).

In the recorded cases studied by McClintock[69] the mortality was over sixty-six per cent. In 34 cases at the Lying-in Hospital the death-rate was thirty per cent. Of 10 deaths at this hospital, 8 occurred when scarlatina had developed within thirty-six hours after delivery. Of 18 patients attacked on the first or second day, 8 died. Of those attacked on or after the third day (16 in number), all but 2 recovered. McClintock also quotes Dr. Halahan's cases, as follows, viz.: 3 patients, ill of scarlatina at the moment of delivery, died; of 5 attacked during the first twenty-four hours, but 1 recovered; of 10 attacked during the second day, but 1 recovered; of 4 attacked during the third day, but 1 recovered. The remaining 3, attacked on or after the fifth day, recovered. Braxton Hicks'[70] contributions to this subject have been most important. He believed that in one-half of the cases the usual symptoms of scarlatina are manifested, and that the disease almost always commences after the third day after delivery. The death-rate will be greater, the earlier after labor the symptoms develop. Though lying-in women are peculiarly liable to scarlatina, they are frequently exposed to its influence without detriment. Women have not seldom been confined in the room, even in the bed, occupied at the same time by scarlet-fever patients, without experiencing the slightest interruption of their normal convalescence; a result that is not astonishing in protected persons if the scarlatinal virus only transmits scarlatina, but which would not be expected were the virus equally competent to communicate septicæmia in these cases. While a large proportion of cases pursue a grave and anomalous course, there are many others in which a perfectly typical scarlatina is observed, without seriously endangering life. Secondary inflammations are not unknown. Metritis, cellulitis, peritonitis, or pyæmia may be developed, but whether these are direct results of scarlatina or of the puerperal condition is undetermined.

Relapses and Recurrences.—There are recorded numerous instances of relapse of scarlet fever within a short period after the original attack, and second or even third attacks after a more or less prolonged interval are well known to occur. By a relapse is meant a second attack of scarlatina that is evidently due to the persistent activity of the influences that excited the first attack. Within a short period (three days after deflorescence in a case of Woldberg's[71]) after the original attack all the symptoms are repeated; the initial disturbances, the fever, the eruption, the angina, and other phenomena, with ensuing desquamation, are developed. It is held that the second attack is but the completion of the first, that it occurs after an incomplete primary attack, and that it tends to be severe in proportion to the mildness of the first, and often to affect in eruption only those parts which were originally spared,[72] imparting thus to the second eruption the appearance of scarlatina variegata. The relapse may be accompanied by complications of throat, kidney, and other disorders, that were not present in the earlier disorder, and *vice versa*. These relapses are usually very rare, but seem to be more frequent in certain epidemics.

Thomas applies the term pseudo-relapse, or *reversio eruptionis*, to those cases in which the exanthem returns before the disorder has entirely completed its course. Trujawsky found the interval between the two attacks to be from seven to ten days, with an average of eight and five-eighths days. The intermissions are completely afebrile. These relapses have been explained by, (1) a recrudescence of the original contagion, and (2) the action of a newly acquired contagion from a source different from the original one. The prognosis is often graver than in the primary attacks. Recurrences or attacks of scarlet fever occurring after a more or less protracted interval, are more common, and are due to fresh infection. They may occur at almost any period. Trujawsky[73] noted, in 300 cases of scarlatina, 18 patients who had had a former attack. Of these 4 were under ten years of age; 10 were over ten years, and 3 were adults. The interval between the attacks varied from one and a half to seven years. Thomas had personal knowledge of a case in which a second attack occurred. Willan never saw one. Many years may elapse between the two attacks, as when a mother who had the disease during childhood again develops it by contagion from her child. Heyfelder himself had a second attack twenty-seven years after the first one. Trujawsky thought that immunity is greater against contagion originating at the home or in the neighborhood of the patient than when it is brought from a distance. A third attack in the same individual may be observed (as in Richardson's case), and there are reports of repeated attacks of scarlet fever. Bernouilli,[74] for example, mentions the case of a woman, fifty years of age, who experienced in rapid succession six attacks of an exanthem indistinguishable from scarlatina. Other similar cases are on record, but their consideration suggests that they may rather have been forms of medicinal eruption. Acute exfoliative dermatitis may also be mistaken for scarlet fever, and may attack repeatedly the same person. Rashes resembling scarlatina may occur in various other affections, such as typhoid fever, small-pox, etc. Hallopeau and Tuffier[75] saw a scarlatiniform eruption in acute rheumatism, in which there were two relapses with intense erythema, followed by copious desquamation. The possibility of all such cases being mistaken for scarlatina should be remembered. It is a rather singular fact that many persons suffer from angina whenever they are brought into close personal relationship with those who have scarlet fever. This is commonly mild, but may occasion serious discomfort. Those who suffer thus from exposure to the scarlatinal influence do not communicate scarlatina to unprotected persons. Mild desquamation is said to have been noted in some such cases. This, however, would indicate a true scarlatinal infection.

Pathological Anatomy.—In most fatal cases every trace of eruption disappears after death. After a very intense exanthem, more or less redness may remain. After malignant cases blood extravasations may present the only post-mortem discoloration. Remy[76] and Neumann[77] have lately investigated the histology of the skin in scarlatina. Remy found the capillaries of the papillary layer dilated and hyperæmic, and filled with leucocytes which were enlarged and of different sizes, but not so large as in leukæmia. The vascular wall was not altered. The epidermis was thickened by increase of its cylinder-cell layer. The horny layer, sebaceous glands, and hairs were unchanged. The sweat-glands were empty and shrunken. Neumann found the cells of the *rete* swollen. In many specimens the prickle-cells were elongated, and here and there formed interspaces in which exudation-cells were imbedded, and into which small blood extravasations often occurred. Exudation-cells extended abundantly as far as the horny layer, and at the orifices of the follicles they were very numerous. The corium was swollen, the fibres thickened, partly separated by proliferation, partly by enormously dilated vessels that were at times bulbous. It is this exudation into the epidermal layers that causes the loosening of the horny layer from its bed, and the characteristic desquamation. Löschner and Fenwick have also noted this infiltration of the *rete*. The latter writer found the basement membrane of the sweat-glands also thickened, and the lining membrane gone in places, but in other places it was increased so as to occlude the sweat-glands. The deeper layers were normal throughout. The scarlet-fever exanthem, then,

consists of hyperæmia with exudation. Remy found the changes he describes, regularly and uniformly distributed.

The throat symptoms, as constant as are those of the skin, are due to lesions that are always recognizable after death. The milder alterations offer nothing characteristic; they are identical with those of pharyngeal catarrhal inflammation. In more intense degree follicular inflammation, with suppuration and ulceration, is superadded, and œdema becomes more prominent. The inflammatory changes extend beyond the pharynx into the buccal and nasal cavities, while parenchymatous tonsillitis and inflammation of the cellular tissues of the throat and neck develop, with, sometimes, extensive gangrene.

According to Härlin (Thomas), scarlatinous angina is specific, and is marked by "a deep, bluish-red injection of the mucous membrane of the tonsils and neighborhood, of the uvula, of the posterior portion of the tongue in the neighborhood of the highly swollen papillæ, of the posterior portion of the region of the cricoid cartilage, and of that portion of the pharynx which includes these different parts, and measures about two inches in breadth." This coloring is said to be sharply outlined in the direction of its transverse diameter. A point of the highest importance is the nature of the diphtheritic membrane so often formed in scarlatinous angina. By most writers it is assumed to be pathogenetically identical with primary diphtheria. Now, while there can be no doubt that primary diphtheria may and does complicate scarlatina, it is almost equally certain that in many cases the membrane is simply a result of the intensity of the inflammation evoked by the action of the scarlatinous virus. In the one case the scarlatinal, in the other a true diphtheritic, poison acting upon the vascular tissues of the throat, causes a coagulation-necrosis that results in the production of the membrane. The lesions of the two processes are identical. They only differ etiologically and in their results. The membrane sometimes extends to the nasal cavity, the larynx, and the trachea. Lewis Smith has seen, in four cases, the diphtheria become dissociated from scarlet fever, and attack other members of a family as idiopathic diphtheria. On the other hand, there is very satisfactory reason to believe that the diphtheritic membrane is most often without the specific nature of primary idiopathic diphtheria. Heubner concludes that scarlatinal diphtheria differs from primary diphtheria clinically and histologically. It begins with a simple catarrhal affection; the change from catarrhal to diphtheritic commonly occurs on the fourth day. Henoch likewise denies that the affection is primary diphtheria. Koven[78] gives some remarkable figures that go to prove the nonidentity of the two affections. His report includes 426 cases. He shows that while it is most uncommon for two infectious diseases to coexist, of 426 cases 125 had necrosis faucium, while at the very time *there was not a single case of idiopathic diphtheria in Christiania.* Moreover, *diphtheritic paralysis was not once observed.* Scarlatinal diphtheria, also, much more rarely than primary diphtheria, extends to the larynx and trachea.

Kidneys.—Friedländer[79] describes three forms of renal inflammation with scarlatina. These are: 1, Initial catarrhal nephritis, the early form; 2, the big, flabby hæmorrhagic kidney, interstitial septic nephritis; 3, glomerulonephritis, nephritis post-scarlatinosa. The first, he asserts, appears at the beginning of the exanthem, or a few days later, and disappears in a few days or weeks. It rarely excites œdema, and hardly ever kills. It is analogous to the alterations productive of the febrile albuminuria of many infectious diseases. Cloudy swelling and proliferation of the tubular epithelium, and, later fatty degeneration, are shown. Within the tubular lumen are hyaline and granular cylinders, round cells, and desquamated epithelium. In the interstitial tissue are scattered round cells. Bowman's capsule is thickened, and there may be a small quantity of albuminous fluid between the capsule and the glomerule. Micrococci are sometimes found in the capillaries and tubules. The large, flabby hæmorrhagic kidney was found in 12 of the 229 scarlatinal necropsies made by Friedländer. It was found especially where the scarlatina had been complicated with diphtheria, abscess, etc. It is not characteristic of scarlatina, but is also seen in primary idiopathic diphtheria. The kidneys are enlarged and soft, and show pronounced cortical changes. The cortex is invaded by small extravasations and larger blood infiltrations. The epithelium is only slightly altered, but the interstitial tissue is thickened and abundantly infiltrated with round cells. Emboli of micrococci are commonly present. It develops between the first and fourth weeks, and proves fatal so rapidly that œdema does not develop. It is an especially severe form of septic nephritis. Glomerulo-nephritis, Friedländer holds to be the only characteristic scarlatinal nephritis. Here the kidneys are firm, often hyperæmic, and resemble the cyanotic kidney, except that the glomeruli do not appear red upon section, but gray and anæmic. They are enlarged and prominent. Alterations are almost limited to them. Their nuclei are enlarged, their coils empty of blood, their walls thickened, their lumina contracted or obliterated. Bowman's capsule is not much thickened. There are also slight interstitial cell infiltration, fatty degeneration of epithelial cells, and hyaline formation in the arteries. The alterations in the glomeruli account for the anuria and uræmia, as well as the rapid hypertrophy of the left ventricle by the obstruction of the renal arteries, as nearly all of the renal arterial blood has first to pass through the glomeruli. Klein,[80] who has given the subject especial attention, in a series of 23 necropsies did not observe the identical glomerulo-nephritis as described by Klebs.[81] Klein's cases had died at various periods between the second and forty-fourth day. Their ages were between two and thirty-six years, the largest number being under twelve years of age. Changes resembling the glomerulo-nephritis of Klebs were observed, but they were only characteristic of the early stages of scarlet fever. A sharp definition between the early and late changes is not practicable. The first set of changes are chiefly limited to the cortex. They are: 1. Increase of nuclei (probably epithelial) covering the glomeruli. 2. Hyaline degeneration of the elastic intima of minute arteries, especially of the afferent arterioles of the Malpighian tufts. The intima of these vessels is swollen here and there into spindle-shaped hyaline masses, causing narrowness of the lumen. There is similar hyaline degeneration of the capillaries of the glomeruli, rendering them often impermeable. These degenerated parts become fibrous in appearance, and Bowman's capsule becomes thickened. 3. A third change is multiplication of the nuclei of the muscularis of the minute arteries, with increased thickness of their walls. This is greatest at the point of entrance into the glomeruli, but is also distinct in other arteries of the cortex and in the base of the pyramids. There are also swelling of the epithelia of the convoluted tubules and proliferation of their nuclei, especially of the tubules close to the afferent arterioles of the glomeruli. In some cases the epithelium of the large tubules of the pyramids is detached. Klein's observations, 1, that the hyaline changes readily affect the arteries near their point of branching, and, 2, that the hyaline substance is of the nature of elastic tissue, agree with the conclusions of Neilson concerning the arteries in various cerebral disorders and in many infectious diseases. He does not think that the anuria and uræmic poisoning in scarlatina, when the kidney does not show conspicuous change, are due to compression of the vessels of the glomerulus by the nuclear germination, as claimed by Klebs, but rather to the changed state of the arterioles, and suggests that the increased formation of arterial muscular fibres, under the stimulus supplied by the disease, may cause a contractility that obliterates the calibre of the arterioles and shuts out the glomerulus from the circulation, and thus, so far as it operates, suppresses the secretion of urine. The parenchymatous changes found in the early stages are slight and difficult to detect, the cloudy swelling and granular degeneration being limited to small portions of convoluted tubules. The second order of changes begins about the ninth or tenth day. They are interstitial as well as parenchymatous. Round cells are found around the larger vascular trunks, spreading

into the bases of the pyramids and into the cortex. This process begins about the end of the first week, and gradually increases until portions of the cortex, rarely portions of the bases of the pyramids, are converted into pale, firm, round-cell tissue, in which the tubules become compressed and obliterated. The parenchymatous element of the nephritis consists in crowding of urinary tubules with lymphoid cells and various kinds of tube-casts, and fatty degeneration of the epithelium of the tubules. This grows more marked with the advance of interstitial changes. The round-cell infiltration of the cortex begins at the roots of the interlobular vessels, spreading rapidly toward the capsule of the kidney, and laterally among the convoluted tubes around the glomeruli, att first between the medullary rays, later it encroaches upon them. Portions of the cortex may be converted into firm, pale, bloodless cellular masses in which Malpighian tufts and urinary tubules become more or less destroyed. In one case renal embolism was encountered ; both interstitial and parenchymatous inflammation was very intense. The kidney was markedly enlarged. Klein also noted deposition of lime in the epithelium and lumina of the tubules, first of the cortex and then of the pyramids, at an early stage of scarlatina, when only slight changes are otherwise shown. He concludes that cases of scarlatina which die after the ninth or tenth day usually show more or less well-marked interstitial nephritis.

Lymphatic Glands.—Peculiar changes have been noted in the lymphatic glands by Klein. In addition to the ordinary inflammatory infiltrations which he describes as occurring in the lymphatic follicles connected with the organs of the throat and in the glands of the neck, the ordinary uninuclear lymph-cells are greatly diminished in number, and are replaced by large granular cells containing numbers of germinating nuclei.

Liver.—This viscus becomes slightly enlarged from cloudy swelling. In one case Klein noticed, after two days' illness, acute interstitial hepatitis. The middle and internal coats of some arteries show the same alterations as in the kidneys. Wagner observed lymphoid new formations and numerous collections of cells and nuclei, especially in the interacinous connective tissue.

Spleen.—In the spleen the changes are uniform and constant. They are : 1. Enlargement of the Malpighian corpuscles. 2. Hyaline degeneration of the intima of the arteries. 3. Proliferation of the nuclei of the muscular coat of the ultimate arterioles, with increased thickness of their walls. 4. Hyaline swelling and degeneration of the adenoid tissue around the degenerated arteries. 5. In the central parts of the Malpighian corpuscles the ordinary nuclei of the lymph-cells disappear, and in their stead are found large hydropic cells containing pigment (Klein). Other writers assert that there is no uniformity in the splenic changes, beyond a slight enlargement. Biermer has observed enormous enlargement of the Malpighian bodies.

Disorders of the alimentary canal are not frequent in scarlatina, and when they occur it is usually in grave cases. They then not infrequently constitute the principal complicating lesion. In the cases of Fleischmann, diphtheritic enteritis was the most common sequel. The peculiar "shaved-beard appearance" of Peyer's patches has been at times observed, and at times these patches and the solitary glands are prominent, reddened, and inflamed, with associated tumefaction of the mesenteric glands (Harley). Barthez and Rilliet show, however, that in cases where the typhoid-like lesions have been discovered, the symptoms shown during life did not resemble those of typhoid fever ; and conversely, cases of typhoid scarlatina cannot be expected to reveal these lesions after death. Enteritis is more often catarrhal in nature. It has been asserted that in scarlatina the exanthem invades the mucous membrane to the same degree as the skin. Post-mortem evidence of this, however, is by no means constant. The glands throughout the alimentary tract are sometimes swollen, and sometimes form small ulcers and extravasations.

Meningitis is rarely the cause of even the most intense cerebral symptoms. Hyperæmia of the brain and meninges, with great venous engorgement, is often seen, but signs of pronounced change are extremely uncommon.

Periosteitis and osteitis occur in connection with affections of the joints, of the nose, of the pharyngeal and aural cavities, and of other parts, but afford nothing characteristic. Neither do the general serous surfaces show peculiar lesions. The condition of the blood and blood-vessels after certain rapidly fatal cases is important. Sometimes the blood is very fluid and black. At other times clots are abundant and firm ; again, it may have become diffused throughout the tissues. Remy has seen all the vessels of the papillary layer of the skin filled with coagulated blood. Thrombosis of the sinuses has been noted after scarlatinal diphtheria (Thomas). Fatty degeneration of the heart following cloudy swelling, with dilatation, occurring particularly in the walls of the right ventricle, is a frequent result of scarlatina, as it is of other infectious disorders.

Diagnosis.—Scarlet fever must be distinguished from measles, rubella (Rötheln), roseola variolosa, scarlatiniform rashes of septic or medicinal origin, certain idiopathic erythemata, and diphtheria. From measles it differs in its shorter incubative stage, and in the characters of its prodromes. In the former affection there are symptoms of coryza and bronchitis, with photophobia, sneezing, and coughing, while in scarlatina the prodromal symptoms especially involve the throat. In scarlatina the eruption begins to appear during the first or second day; in measles during the third or fourth day. During the course of scarlatina there is an absence of catarrhal symptoms for the most part. There are the characteristic sore throat, the peculiar "strawberry tongue" (after the first two or three days), the well-defined eruption, the more protracted fever, the pronounced desquamation, and the tendency toward renal complications. The eruptions differ both in their development and distribution in the two affections. In scarlatina the face is characteristically invaded by the eruption, which entirely spares the area about the mouth, and is nowhere copiously developed in this region; while in measles the eruption is, probably, most intense upon the face. The macules in measles are large, irregular, and mostly papular. In scarlatina the eruption is punctate and more regularly distributed, not elevated ; it is scarlet in color, and generally coalescent, while in measles it is more discrete, elevated, arranged very extensively in forms of crescents and segments of circles, with greater or smaller areas of healthy skin between the lesions, and is of a darker raspberry color. In measles the stage of eruption lasts from three to four days, and begins to decline as soon as the eruption upon the lower extremities becomes complete. It occupies about thirty-six hours in attaining its acme. In scarlatina this stage lasts from two to six days or more. It attains its acme in about eighteen hours. In measles there is a rapid return to a normal temperature in uncomplicated cases, while in scarlatina both eruption and fever decline more slowly. The conjunctival, nasal, and bronchial catarrh of measles is absent in scarlatina. In measles the tongue remains coated throughout. Sore throat is constant in scarlatina, quite uncommon in measles, and when present is almost invariably only catarrhal. The fever in scarlatina is at once more intense and more protracted. The desquamation of scarlatina is pronounced and lamellar; that of measles insignificant and branny. Scarlatina is frequently complicated by diphtheritic pharyngitis and renal inflammation, measles by inflammations of the respiratory apparatus.

The eruption of rubella (Rötheln) more closely resembles that of scarlatina. It is paler, more discrete, and its lesions are larger and more distinctly papular. It is more transitory, and fades almost without desquamation, which, when present, is branny. Rötheln, moreover, has a longer incubation, almost no prodromal stage, sometimes marked catarrh, and but slight elevation of temperature. It is feebly contagious, of much shorter duration, and is hardly ever followed by nephritis and dropsy. The diagnosis is difficult only when the eruption of rubella becomes confluent. Here, however, the

confluence involves certain areas. It is sharply circumscribed by normal integument, and shows in contrast the outlying characteristic lesions. It is of a pale rose-red, and not of a scarlet color, and is accompanied by the peculiar symptoms of rubella, and rarely lasts more than thirty-six hours. Both measles and rubella may at times closely resemble the milder forms of scarlatina, and from the eruption alone the diagnosis may be difficult; but a consideration of all the symptoms will usually lead to correct conclusions. Roseola variolosa should only excite embarrassment when it occurs before the peculiar eruption of small-pox has appeared. It is less general, is more like a simple diffuse erythema than is scarlatina, and is so speedily followed by the characteristic vesicular eruption that doubt will soon be dissipated. Its coexistence with the essential eruption may excite suspicions of a concurrence of scarlatina and small-pox. Such an error may readily occur. Obstetrical and surgical scarlatina have already received attention. When erythema begins near a wound and becomes scarlatiniform in spreading, a septic origin must usually be allowed, though instances of scarlatina thus beginning have been reported; otherwise, septic erythema is more circumscribed and irregular. Scarlatina in the wounded and in lying-in women may be perfectly typical. Medicinal eruptions have unquestionably been at the bottom of many errors of diagnosis. It has been shown that many drugs may excite eruptions and general symptoms very like those of scarlatina; but for the most part they are simple active hyperæmias, such as are produced by the action of belladonna upon the cutaneous arterioles. Such eruptions differ from that of scarlatina in the absence of prodromes, and, usually, of fever. They are also mostly partial and without the history, course, or results of scarlatina; but at times, and especially when they follow the ingestion of preparations of cinchona, the whole complex of scarlatinal symptoms may be accurately simulated. The conditions for diagnosis have already been pointed out. In second or repeated attacks of so-called scarlatina, due consideration of the possible influence of drugs as an etiological factor will, doubtless, convert some very puzzling cases into very simple ones. Acute exfoliative dermatitis and desquamative scarlatiniform erythema[82] may well be mistaken for scarlatina upon their first appearance. The rash is more protracted than in the essential fever, and is less abrupt in its onset. The local symptoms are very marked, while the constitutional phenomena are usually insignificant. The desquamation may begin while the eruption is in full florescence. These affections are not contagious and have no specific sequelæ. An erysipelatous eruption may be like that of scarlatina. It, however, differs markedly in its distribution, its evolution, and course, being never universal, always progressive, and of indefinite duration. The subjective symptoms are quite different in the two affections; the erysipelatous eruption is painful both spontaneously and on pressure. Much œdema accompanies the latter eruption. Diphtheria may complicate scarlatina, and the intensity of the local inflammation may induce a coagulation-necrosis exactly corresponding to the membranous formations of diphtheria. Idiopathic diphtheria may especially resemble scarlet fever when it is accompanied by the erythematous exanthem that is sometimes developed, either early in the disorder, or later, in cases of blood-poisoning. At first it may not be possible to arrive at a correct diagnosis. According to Robinson,[83] in the early diphtheritic erythema there is no marked elevation of temperature. The rash may begin in any region, and rarely extends to the whole surface. The tongue is not affected, and there may be no special general disturbance. Desquamation does not occur. The late diphtheritic erythema is septic. When the eruption of scarlatina is imperfectly developed, or when it does not appear at all, and when sore throat and fever are the only symptoms to attract attention, the diagnosis must rest upon the history of the patient and his surroundings, and upon the course of his illness. In not a few cases a retrospective diagnosis of scarlatina must be made, after the occurrence of desquamation or the supervention of nephritis and dropsy under condi tions that indicate their scarlatinal origin.

Prognosis.—The mortality from scarlet fever varies widely in different epidemics. From the affection that in Sydenham's time "hardly deserved the name of disease," to a pestilence of intense malignity, all degrees of fatality have been, and continue to be, observed. Epidemics have been recorded in which no deaths have occurred. Recently Whitla[84] has recorded but a single death in 133 cases of scarlatina treated in hospital. Such results are, unhappily, exceptional. The mortality has been known to reach thirty and forty per cent. An excessively high rate of mortality is, in great part, attributable to epidemic tendencies toward grave complications, diphtheria, nephritis, etc. In private practice the death-rate will not often exceed ten per cent. In hospitals the percentage of deaths is usually much higher, the result being due to the fact that milder cases are kept at home for the most part, and not to differences in social condition, except in so far as neglect and exposure previous to admission may have aggravated an attack or have excited a complication. The death-rate will be high or low in accordance with the type of the prevailing epidemic, and the average mortality of the disease should always be considered with reference to this. Neither season nor atmospheric condition appears to exert any influence upon the epidemic type. Likewise, telluric conditions do not modify it. Benign and malignant epidemics follow each other without evident cause. The mortality at the beginning and during the height of an epidemic is greater than during its decline. Barring the effects of extreme poverty and exposure, scarlet fever affects the rich and poor impartially. The sexes are almost equally attacked, but age exerts a striking influence upon the result. Children under one year of age, though less apt to be attacked, are especially liable to fatal forms of the disease. According to Fleischmann, the mortality at St. Joseph's Hospital was: Under one year of age, seventy-five per cent. (8 cases, 6 deaths); from one to four years of age, forty-three per cent.; from five to twelve years of age, 19.6 per cent.; the total mortality being ten per cent. The majority of deaths occur under the sixth year of age; with increasing years the prognosis becomes more favorable. Fleischmann's records show a higher mortality than those of some other writers. For example, Kraus gives 4 deaths in 13 cases less than one year of age; 29 deaths in 113 cases from the close of the first to the close of the fifth year of life; 10 deaths in 106 cases from the end of the fifth to the close of the twelfth year of age; and 2 deaths in 40 cases from the twelfth to the twentieth year of age. Voit reported 1 death in 5 cases less than one year of age; 24 deaths in 166 cases from the first to the close of the sixth year of age; 10 deaths in 109 cases from the sixth to the twelfth year of age. Roset reported 16 deaths in 43 cases less than one year of age; 31 deaths in 156 cases from the first to the close of the fifth year of age; and 3 deaths in 88 cases over five years of age.[85] An exception must be noted to the favorableness of the prognosis in persons of maturer years, in the case of puerperal women, in whom scarlatina has already been shown to be especially malignant. No case can appear to be so mild as to justify a prognosis unqualifiedly favorable. From the beginning until the termination in recovery there is no period when a sudden change may not place the life of the patient in jeopardy, whether by an aggravation of the essential symptoms of the disease, or by the supervention of complications. The prognosis, however, is generally favorable if the disease pursue a regular course; if the eruption follows a brief prodromal stage, and is regularly developed; if the fever, more or less intense from the first, does not exceed at the height of the eruption 40° C. (104° F.), and, steadily falling, reaches the normal on the sixth, seventh, or eighth day; if the angina do not assume a diphtheritic character, and is not complicated by parenchymatous tonsillitis, retropharyngeal abscess, or cellulitis of the throat or neck; if the kidneys remain unaffected or show only slight evidences of disorder. On the other hand, the prognosis is more grave when the eruption appears after a prolonged

prodromal stage, or when the attack is ushered in by convulsions or other profound nervous disturbance; or when the temperature reaches a high degree, 40.6° to 41° C. (105° to 106° F.), at once; or when intractable vomiting is present; or when diarrhœa is a prominent feature; or when the pulse beats more than one hundred and twenty times to the minute, and is feeble, unequal, and irregular; or when the throat is ulcerated and develops diphtheritic inflammation; or when suppurative, parenchymatous, or gangrenous inflammation of the tonsils, or retro-pharyngeal abscess supervene; or when the neck becomes swollen, brawny, and livid from glandular, peri-glandular, and diffuse cellular inflammation. Apprehension should always be excited if the eruption come out imperfectly or irregularly while the fever is intense; or if, once fully developed, it suddenly fade; or if the eruption assume a livid color or a distinctly hæmorrhagic character. A coppery hue of the eruption is unfavorable, as is also a livid coloration of parts not invaded by the eruption. Small, scattered petechiæ in the midst of an otherwise normal eruption are unimportant. Miliary vesicles, developing in the ordinary course of the fever are insignificant; occurring later, during an attack of unusual severity, they are often the forerunners of death. Convulsions first occurring after the height of the fever, are more ominous than if occurring earlier. Should the eruption, and especially the fever, continue unabated after the usual period, dangerous complications are to be apprehended. Coma is of grave augury, as indicating uræmia, œdema of the brain, or even meningitis. Nephritis is more serious the earlier it is developed. It occasionally happens that scarlet fever at first shows the symptoms of a mild attack, but before the completion of the eruption assumes a malignant character. If symptoms of malignancy occur after the completion of the eruption, they are usually attributable to complications. On the other hand, all the signs of malignant scarlatina may be present at the outset. High fever, rapid pulse, convulsions or coma, protracted vomiting, intense eruption, may all yield after the second or third day, the disease thenceforward pursuing a mild course; again, symptoms of malignancy may disappear upon the supervention of a delayed eruption. Mayer[86] observed a temperature of 43° C. (109.4° F.) on the evening of the second day. The temperature subsequently varied slightly until the fourth day, when, upon the appearance of the eruption, it subsided. The occurrence of scarlatinal diphtheria always increases the danger of death. Heubner regards its sudden extension to the soft palate and to the portals of the œsophagus and trachea as certainly to be followed by death within from twenty-four to forty-eight hours, the fatal issue occurring either through gradual progress of gangrene, by inflammation of the lymphatic glands and connective tissue of the throat and neck, or by *œdema glottidis*. When circumscribed spots are invaded and the lateral portion of one tonsil shows the first patch, from which the membrane gradually spreads, recovery may occur. Diarrhœa persisting during the attack greatly increases the danger. Nephritis is always a serious complication, though terminating favorably in most cases. The danger is usually proportionate to the earliness of its occurrence. Death may occur as in ordinary nephritic inflammation. Scarlatinal nephritis most rarely becomes chronic. Inflammation of the organs of hearing, while rarely imperilling life, often results in partial or complete deafness. This, according to Burkhardt-Merian,[87] depends upon croupous-diphtheritic inflammation primary in the throat. The prognosis is more unfavorable if the process be allowed to go untreated. Rheumatic and rheumatoid inflammations are not commonly dangerous complications. Endo- and peri-carditis, pleurisy, peritonitis, meningitis, pneumonia, dysentery, parenchymatous degeneration of the heart, etc., are all complications of extreme danger. Purulent inflammations of pyæmic origin usually constitute sequelæ of scarlatina, and are of the gravest importance.

TREATMENT.—Mild cases of scarlatina require little more than good nursing. As soon as the nature of the disease has been recognized, the patient should be removed to a clean, well-ventilated room, supplied with only such furniture as is indispensable. Only the attendants of the patient should be admitted to the sick-room. All superfluous articles of clothing should be discarded. As far as practicable, woollen outer garments should not be worn. In summer the windows should be kept open sufficiently to secure free movement of air and agreeable temperature; in winter an open wood or coal fire should, if possible, be kept constantly burning. The temperature of the room should not exceed 21° C. (70° F.), nor fall below 18° C. (65° F.). The patient, unless an infant, should be kept in bed even during the mildest attack. The bed-covering should be sufficient to secure comfort, nothing more. The diet should consist in easily assimilable food; the nearer this approaches a pure milk diet the better. Cold drinks may be allowed; cold water, lemonade, raspberry vinegar properly diluted, soda-water agreeably flavored, are grateful to the patient and preferable to warm and mucilaginous drinks. Though milk should form the principal article of food, light broths and soups, beef-tea, chicken-jelly, and, especially during convalescence, the various appetizing and wholesome preparations of food now so abundantly supplied, may be given. Clothing and bed-clothing may be frequently changed under precautions providing for appropriate disinfection. In such cases internal medication may be held in reserve, a careful observation of all symptoms being meanwhile maintained; the condition of the kidneys being systematically ascertained by daily observation. For the angina, if this does not exceed a simple hyperæmia, soothing gargles of flaxseed, sage, or chamomile tea, or of decoction of quince-seed, will prove efficacious. Should the throat develop the whitish curdy deposits of follicular inflammation and the erosions that so often accompany acute catarrhal pharyngitis, a mildly antiseptic gargle will act beneficially and will correct fetor of breath, and, to some extent, disinfect the secretions and exhalations. For this purpose one of the subjoined gargles may be employed:

℞.	Acid. carbolic. cryst.	ʒ ss.
	Glycerin	f ʒ j.
	Aq. destil. q. s. ad	f ℥ vj.
M.	Sig.—Gargle.	

Or,

℞.	Tinct. ferri chlorid.	f ʒ j.
	Potass. chlorat.	ʒ ss.
	Glycerin	f ʒ j.
	Aq. destil. q. s. ad	f ℥ viij.
M.	Sig.—Gargle.	

External applications to the throat are often useful. A favorite domestic remedy is a strip of bacon-rind applied to the skin of the throat. It produces a slight vesicular eczema, and is probably of some advantage as a counter-irritant. Obviously, such applications are inadmissible when diphtheritic inflammation is present. Mildly stimulating liniments are more handy and elegant, and quite as efficacious. The itching and burning of the eruption will be greatly alleviated by inunctions with camphorated oil, cold cream, vaseline, or lard. This practice is especially commended as restricting the spread of contagious particles. Tepid bathing or sponging under the bed-covering is refreshing to the skin and nervous system, contributes greatly to bodily comfort, and may be practised several times daily. Although every case demands constant watchfulness, when the temperature does not exceed 39° C. (102.5° F.) medication beyond that mentioned will not be called for, unless complications develop. When the degree indicated is exceeded, marked benefit will be derived from antipyretic remedies. These may be administered internally or externally. Of internal antipyretic remedies, until recently, the most popular was quinine. The sulphate may be prescribed in capsules, in doses of from three to five grains to a child five years of age, at intervals of two hours, for two or three doses. It must be confessed, however, that in scarlatinal hyperpyrexia quinine is at best an uncertain and feeble remedy. In severe cases there is often intractable vomiting, and quinine is

especially apt to be rejected almost as soon as swallowed. It is better, therefore, to give it in solution by the rectum or hypodermically. By the latter method a solution containing four grains of the hydrobromate of quinine in twenty minims of water, or of the muriate of quinine with urea,* may be injected once or twice daily. Other agents occasionally used for the reduction of fever are aconite and veratrum viride. In mild cases, however, they are unnecessary, and in severe ones they are both unsatisfactory and unsafe. Salicylate of sodium possesses positive antipyretic properties, and may be used in scarlatina with frequent benefit. The synthetically prepared alkaloids of the aromatic series of carbon compounds, of which thallin, antipyrin, and antifebrin may be considered the most reliable and safest for the reduction of temperature, are probably the most valuable remedies by the internal administration of which exalted temperature may be reduced. These drugs, which promise to hold a firm position in therapeutics, will most probably serve a very useful purpose in the treatment of scarlatinal hyperpyrexia. At present, however, observation has not been sufficiently extended to justify definite conclusions. Antipyrin acts well with children, and seldom produces objectionable diaphoresis or eruptions. Argutinsky recommends the following minimal doses of this agent: For children under one year of age, three grains thrice daily, at intervals of three hours; for those of from one to three years, five grains; for children between this age and five years, from five to six grains three times daily, at intervals of two hours; for children of from six to eight years, from eight to ten grains daily, at intervals of two hours; and for children of ten or twelve years, from ten to twelve grains thrice daily, at intervals of one hour. Thallin may also be used to effect the same purpose. The dose of thallin is about one-fourth of that of antipyrin. There is a somewhat greater tendency to collapse after thallin than after antipyrin, and, therefore, the earlier doses should be given very cautiously. Antifebrin affords advantages over either of these agents. Vomiting most rarely occurs after its use. The dose is one-half of that of antipyrin, though its full action is produced more slowly. Neither is sweating quite so constantly produced, though a pronounced cyanosis of the cheeks and mucous membrane and of the extremities is often observed. These agents are also active when administered by enema.

During the administration of these drugs the thermometer should be constantly employed, care being taken to avoid collapse. After a few hours the influence of the dose fails and recourse must be had to them repeatedly. By far the safest and surest agent for reducing temperature in scarlatina is cold water. This may be applied in various ways. The simplest method is by frequent spongings with cold or tepid water under cover of the bedclothes. At the same time cold wet-cloths may be applied to the head, and the patient may be permitted to suck small pieces of ice. In most cases it is better that the water be warm. The spongings may be repeated frequently during the day and night. In cases where, with an elevated temperature, the eruption develops incompletely, or is much delayed in appearance, the body may be immersed in water somewhat cooler than its normal temperature. A cool bath (27° C. = 80° F.) has been extolled as of singular virtue in such cases, and at times it is of the highest value. The tepid, even the warm bath, is probably of equal benefit in most cases. Recent writers have denied that efforts to "bring out" an imperfect or delayed scarlatinal eruption are of any avail. There can be no doubt, however, that treatment with this object in view is often successful. The hot bath, even with the addition of mustard, by exciting cutaneous hyperæmia, will often relieve the congestion of internal parts. Warm and hot drinks made from various vegetable substances were formerly much employed to "bring out" the eruption. They were given copiously, and often in combination with such diaphoretics as spiritus mindereri, spirits of nitrous ether, etc. This plan of treatment is not much practised to-day. The cold bath, which should be of a temperature not lower than from 24° to 27° C. (75° to 80° F.), should be reserved for cases whose temperature exceeds 40° C. (104° F.). The body should be immersed but for an instant, the benefit of the plunge consisting largely in the dilatation of the vessels of the skin through reaction. The cold pack is also of value in these cases. When the temperature steadily rises to an alarming degree, or when hyperpyrexia is developed almost at the outset; when, with or without well-developed exanthem, stupor or coma, or other grave nervous disorder, arises, and when the pulse becomes very rapid, feeble, and irregular, the maintenance of life depends upon the reduction of temperature. Here it is impossible to give hard and fast rules for conduct. Water below the normal temperature of the body still remains our most efficient means of reducing the excessive heat. The lower the temperature of the bath, the more rapidly is this result attained, but the shock of the sudden contact with the cold water may exert a depressing effect that may not speedily pass off. The body cannot remain in very cold water longer than a minute or so without exciting chattering of the teeth, lividity about the mouth, and a pinched appearance of the features and of the surface. Cold affusions may often be most profitably employed. They were strongly commended by Currie. The affusion may be practised by pouring from a pitcher, from a moderate height, cold water upon the head of the patient, until the necessary fall of the temperature has been achieved. The warm bath (32° to 35° C. = 90° to 95° F.) has been highly extolled as favorably influencing the course of scarlet fever when used at the very beginning. Thompson employed it thus constantly, and never lost a case treated in this manner. In a bath of from 27° to 30° C. (80° to 85° F.) the patient may remain for five or ten minutes. These baths should be repeated as often as the temperature of the body becomes as high as 39.5° to 40° C. (103° to 104° F.). To avoid alarming the little patient, the bath-tub may be covered with a sheet or blanket. Placing him upon this, he may slowly be lowered into the water. Upon removal from the bath the patient should be wrapped in a dry blanket. As the body soon dries under the protection afforded, rubbing with towels may be avoided. The skin should now be anointed with oil or other agreeable fatty substance. Refreshing quiet and sleep often follow this bath. In using the wet pack, a blanket may be spread upon a hard couch or bed covered with oil-cloth; upon this a sheet wrung out in cold water is laid. The naked patient is stretched upon this sheet, which along with the blanket is wrapped about him snugly. The brief sensation of chilliness is soon replaced by one of warmth, and after a few moments the body breaks out into copious perspiration. This may be encouraged by hot drinks, and hot bottles to the surface. The patient should not remain too long in the pack, otherwise hyperpyrexia may rather be increased than diminished. In the intervals of the baths, in extreme cases, an ice-cap may be worn, and cloths wrung out in iced water may be applied to the epigastrium. Nothing can exceed the efficacy of the above-described method of treating scarlet fever with high temperature; but to secure its full influence, it must be pursued systematically and intelligently. The thermometer must constantly direct the actions of the physician. The prejudices of friends and attendants against the immersion of the fevered body in ice-cold water will not extend to the use of tepid and cool baths, from which, indeed, equally good results may be obtained. The baths may have to be repeated at intervals of two or three hours for days before the fever begins to yield; or they

* This salt, which is also called "quinia bimuriatica carbamidata," is prepared by Andrews & Thompson, of Baltimore, as follows: Muriate of quinine, 793 grains; muriatic acid (specific gravity 1.070), 500 grains; pure urea, 120 grains. Mix the muriate of quinine in the Hcl in a porcelain capsule, and when it is dissolved add the urea and heat carefully over a water-bath until sufficiently concentrated to form crystals (evaporation to dryness under a low temperature may be practised). To prepare the solution for hypodermic use, take of muriate of quinine and urea, ʒ ij.; of distilled water, f ℥ j. Dissolve and filter. Twenty minims of this solution contain five grains of muriate of quinine. For hypodermic use this solution leaves nothing to be desired.

may unhappily altogether fail to control the irresistible intensity of the disease. On the other hand, they frequently exert a most gratifying influence upon the course of the malady, the temperature becoming permanently reduced, the pulse quieter, fuller, and regular; jactitation, delirium, and coma being replaced by composure, consciousness, or natural sleep. Often an attack that appeared about to pursue a malignant course, under the influence of the bath becomes benign and terminates favorably. While exalted temperature that threatens to destroy life can, in the manner indicated, often be reduced, the course of the disease itself cannot be aborted. No remedy is known that can be said to exert a specific influence over it. Vaunted specifics have not withstood the test of experience. Bennett claimed to have never lost a case of malignant scarlet fever, a result that he attributed to the administration of fresh yeast, in one or two tablespoonful doses, several times daily. One no longer hears of Schneemann's plan of rubbing the surface with bacon, and of Deline's oil inunctions as curative, though the value of such adjuvant treatment is universally recognized. Recently Hayward [88] reported several cases of malignant scarlatina successfully treated with crotalus. The agent was applied to the denuded surface of the throat, and was also given internally. The mineral acids, though highly extolled by authors, do not confer any signal advantage in the treatment of scarlatina. Acetic acid has been supposed to exert a favorable influence over the disease, and is a favorite remedy. Probably the most popular routine treatment of ordinary scarlet fever is that of carbonate of ammonia. By many it is considered to have a specific influence. When in cases of very elevated temperature the heart-action flags, the pulse becoming rapid, feeble, and unequal, when delirium or stupor appears, the preparations of ammonia are demanded. The carbonate, in doses of one to three grains to a child five years of age, may be given every third hour in aqueous solution with milk, which in a great measure destroys the pungent, disagreeable taste; or it may be given in solution of the acetate of ammonia, a most commendable combination. The aromatic spirits of ammonia may be employed for the same purpose. Hoffman's anodyne, whiskey, or brandy is especially indicated when the nervous system shows alarming signs of perturbation, delirium, jactitation, stupor, etc. Purgation, which should usually be avoided, may at times become necessary. Small doses of calomel (one-sixth to one-fourth grain) repeated every hour, until the bowels are moved, generally act well. Castor-oil is a harmless and safe, but nauseous, agent. Rhubarb and scammony are also efficient cathartics. Either may be given in doses of five grains to a child six years of age. The taste of scammony resin is not unpleasant, but its difficult miscibility with water is an objection to its use. Ringer recommends as a purgative for children a few drops of a solution of one grain of podophyllin in a fluid drachm of alcohol given in syrup. When depression is profound, reliance should be placed on enemata in preference to active cathartics. During the progress of the disease the expectant plan of treatment is most to be recommended. The daily bath or sponging should be continued. It is probable that renal complications are thus frequently avoided. As the fever and eruption decline, a more liberal, but always easily assimilable, diet should be allowed. The patient should be jealously guarded from draughts and dampness, and even the mildest cases should be kept in bed for at least ten days after the cessation of fever; nor should the patient be allowed to leave his room before the expiration of the third week. Out-of-door exercise cannot be resumed in disregard of season, or of barometric and thermometric variations. In midsummer, when windows and doors must remain open, the question of out-of-door exercise is rather one of danger to others than of personal risk; while in spring, autumn, and winter the risks of exposure are especially great. During these seasons the patient should not venture into the open air before the sixth or seventh week of perfectly normal scarlatina. During convalescence the daily baths should be continued until desquamation is completed, and daily inunctions with oil both expedite this process and minimize the dangers of contagion. No further medication, or at most a ferruginous tonic, will be required.

Unfortunately, during the course of scarlatina there constantly arise complications frequently demanding more energetic treatment than the original malady. Of these the most common (indeed, in its milder degrees it is essential) is pharyngeal inflammation. The milder grades of this will require no more active treatment than that already described. Where the inflammation is more severe, and accompanied by more or less superficial ulceration, applications should be made with a probang or camel's-hair pencil, or by means of the spray. When the surface is foul and covered with offensive exudation, an excellent application is the following, first recommended by J. Lewis Smith:

℞. Acid. carbolic .... gr. iij.–vj.
Liquor ferri subsulphat............ f ʒ ij.
Glycerin........................ f ʒ vj.
S.—Apply with a brush three or four times daily.

Or the following:

℞. Tinct. iodinii .... f ʒ j.
Glycerin........................ f ʒ vij.
M.

Or,

℞. Acid. boracic .... ʒ ss.–ʒ ij.
Aq. destil........................ f ℥ vj.
M. S.—Apply with a brush. This may also be used with the atomizer.

Most therapeutic agents may be profitably given through the hand-atomizers in the case of children intelligent enough to assist by inhalation. Subjoined are suitable formulæ:

℞. Tinct. ferri chloridi................ f ʒ j.
Potass. chlorat .... ʒ j.
Acid. sulphuros.................. f ʒ ij.
Spts. vin. gallic .... f ℥ j.
Glycerin.......................... f ℥ ss.
Aq. destil ....q. s. ad f ℥ vj.
M.

℞. Aq. chlori.......................... f ℥ ss.
Aq. destil .... f ℥ vss.
M.

The various carbolized sprays are most extensively employed. Diphtheritic inflammation calls for the same treatment as idiopathic inflammation.* Cauterization with silver nitrate, acid nitrate of mercury, chromic acid, or other agent, should not be practised. As a gargle in diphtheritis faucium permanganate of potash is valuable.

℞. Potass. permanganat .... f ʒ j.
Aq. destil .... f ℥ iv.
M.

Tracheotomy should never be performed. A case of scarlatinal diphtheria which presents the symptoms that demand this operation, in the idiopathic disorder, is beyond the resources of surgical art. Inflammation of the lymphatic glands of the neck and of the adjacent connective tissue may be treated first by inunction of oil or cerate. In severer forms, cold wet applications, and where suppuration threatens, flaxseed, or cornmeal, or hop poultices should be applied. Suppurating points should be incised early and freely to prevent burrowing. Gangrenous inflammation may sometimes be arrested by strong caustics. Iron, quinine, stimulants, and nourishing and supporting food should be administered in these conditions with a free hand. Nasal catarrh will not usually require treatment. When diphtheria extends to the nasal passages, similar applications to those made in throat

* Dusting powders of subnitrate of bismuth and salicylic acid, and, under proper precautions, of iodoform, is often most useful.

diphtheria should be made through a nasal syringe. Scarlatinal aural inflammation calls for more special treatment; the nasal douche should be used and the diphtheritic pharyngeal and nasal cavities should be repeatedly syringed with antiseptic solutions, for it is by the extension of the inflammation along the Eustachian tube, that the severer forms originate. When the aural inflammation is established, inunctions of mercurial ointment, or of the oleate of mercury, or of iodoform ointment, should be made about the ear several times daily. When the tympanic membrane becomes strongly injected and bulges outward, paracentesis for the release of the pent-up exudation should be performed. Timely tapping of this membrane will often preserve the imperilled sense of hearing. This operation is especially commended by Buck and Olshausen. It is simple and very easily performed. The sensitiveness of the membrane may be obtunded by the instillation of a four per cent. solution of muriate of cocaine. Pomeroy's directions for performing the operation are as follows: "A good-sized speculum is introduced into the meatus. Then an ordinary broad needle, about one line in diameter, with a shank of about two inches, such as oculists use for puncturing the cornea, should be held between the thumb and fingers, lightly pressed so as not to dull delicate tactile sensibility. The part being well under light, the most bulging portion of the membrane should be lightly and quickly punctured with a very slight amount of force. The posterior and superior portion of the membrane is most likely to bulge. The chorda tympani nerve usually lies too high up to be wounded. The ossicles are avoided by selecting a posterior portion of the membrane. After puncture the ear should be inflated by an ear-bag whose nozzle is inserted into a nostril, both nostrils being closed, so as to force the fluid from the tympanum. The puncture may need to be repeated at intervals of a day or two, provided that the pain and bulging return."[69] When pain and tenderness only are present, hot fomentations to the external ear, and to the parotid and mastoid regions, are very soothing. Laudanum and sweet oil, or a two to four per cent. solution of sulphate of atropia instilled warm into the external meatus, often give relief. Frequently renewed solutions of cocaine are very efficacious. Bags of hot table salt, or of heated flowers of hops, are well-known domestic remedies. When perforation occurs spontaneously the hearing may be preserved, but partial deafness is often permanently established, and sometimes the sense of hearing is totally abolished. In such cases the ear should be frequently syringed with warm water, or warm solutions of boracic acid. Iodoform, however, is by far the most effective application in chronic aural inflammation with perforation, with or without necrosis of the bones of the aural cavity. Its disagreeable odor may be masked by adding to the phial a drop or two of some essential oil (cloves, citronella, cinnamon, etc.). Granulations and polypi developing in the course of chronic otitis may be benefited and even cured by astringent powders and washes. Surgical interference will at times be necessary.

When nephritis arises in the course of scarlet fever, or as a sequel, prompt measures for its relief must be adopted. Where it forms a feature of rapidly fatal malignant scarlatina, it may have no time to develop symptoms, or these may escape detection, or the virulence of the disease may throw the renal disorder into the background, or render attempts to treat it futile. In milder cases, and later, during the latter part of the first or during the second or third week, especial attention may be devoted to the treatment of nephritis. Slight albuminuria will occur, according to Mahomed, during convalescence, associated with constipation and a hard pulse, indicative of high arterial tension, without subjective symptoms, and remediable by a brisk purge. This author also asserts that a slight chilling of the surface is sufficient to cause transitory albuminuria. The patient should therefore be carefully protected, in the manner already indicated. Dietary management will go far toward preventing renal complications. A rigid milk diet, in all cases of scarlatina, is regarded by Jaccoud as absolutely preventive of nephritis. Though this may be an extravagant statement, it is certain that in scarlatina there is no better diet than one of milk. Should nephritis arise, it is the more important that the milk diet should be continued. From two to three or four pints may be given during the twenty-four hours, in small quantities, at brief intervals, the latter amount being sufficient for an adult without other food. If there are reasons why milk cannot be taken, light broths and soups and chicken jelly may be substituted, together with light farinaceous food. Buttermilk may, at times, be preferred, and bonny-clabber and slip or junket (milk sweetened and flavored and coagulated with liquid rennet) are often relished, and are excellent articles of food. Proper regard having been paid to the hygienic surroundings and nutrition of the patient, a brisk hydragogue cathartic should be administered, unless diarrhœa be already present. For this purpose there is nothing better than the compound jalap powder. For a child, from five to twenty grains of this should be ordered every night, as required, the object being to secure several watery actions of the bowels every twenty-four hours. The proper dose for an adult is one drachm. The desired watery stools may also be readily secured by the saline cathartics if given in concentrated watery solution, as has been shown by the researches of Dr. Matthew Hay. The more drastic purgatives will rarely be required, except in uræmic intoxication and in extreme dropsy, when podophyllin, croton-oil, elaterin, etc., may occasionally be employed with benefit. When dropsy is but slightly pronounced, purgation may not be required.

The action of the skin should next demand attention. Frequently during the day the body may be wrapped in flannels, wet or dry, as hot as can be borne; or the wet pack may be applied. When available, the steam bath or hot-air bath is to be strongly recommended. The hot-plunge bath may also be employed most advantageously. Pilz has especially lauded this treatment. It should be used after the method of Liebermeister, by gradually increasing the temperature of the bath from 36° C. to 40° C. (96° to 104° F.), in a half-hour. Under its daily use dropsy speedily disappears. Diseases of the heart and lungs, while not positively contraindicating this plan of treatment, necessitate great caution in its application. Sudden chilling of the surface after the bath should be avoided. The imminence of the danger is usually proportionate to the degree of impairment of the function of the kidneys. In giving remedies to modify their action, none calculated to increase their hyperæmia should be employed. Exception can hardly be made in favor of juniper, which enjoys with some writers considerable reputation in scarlatinal nephritis; but digitalis, the pharmacological position of which is not as yet definitely determined, has received very general approval as a most useful diuretic in acute nephritis. From one fluidrachm to a half fluidounce of the infusion (which is much the best preparation for the production of diuresis) may be given three or four times daily, the dose varying with the age of the patient. Its effects, however, are hardly as happy as when dropsy is associated with, or dependent upon, cardiac weakness. Diuretics that act specifically upon the secreting cells of the urinary tubules, the sedative or refrigerating diuretics, are to be preferred, as a rule, in the treatment of scarlatinal nephritis, and will often achieve most astonishing results. Of these the salts of potash are most efficacious—the citrate, the acetate, the bitartrate, and the bicarbonate. For slight nephritis and anasarca a lemonade made with bitartrate of potash will be taken with avidity, and will often almost magically increase the quantity of urine, reduce the dropsy, rapidly diminish the albuminuria, and cause a radical change for the better. This lemonade may be made by adding one drachm of cream of tartar to a pint of boiling water, into which a sliced lemon has been dropped. This quantity, properly sweetened, may be drunk during the day by a child five years of age. Water may be allowed freely, or any of the mild domestic infusions may be substituted for it, their virtue residing principally in the amount of fluid. Dickinson especially recommends the free use of

water as unirritating, and tending to wash out of the tubules the exudate choking up their lumina. In more severe cases, where life is threatened through one or another form of uræmia, very energetic treatment will be required. Jaborandi may now prove useful. J. Lewis Smith, Hirschfeld, and others have commended its action highly. For a child two years of age, one-twentieth of a grain of pilocarpin may be given by the mouth every fourth or sixth hour, or the same amount may be injected hypodermically. Both diuresis and diaphoresis will be promptly increased, and in favorable cases the uræmic symptoms will disappear. Uræmic coma and convulsions, developing suddenly or after progressive renal embarrassment, should be treated without reference to the scarlatina and upon general principles. A remedy of most undoubted value, at least for the control of convulsions, is chloral, which, if the patient be unable to swallow, may be injected in full doses under the skin or into the rectum. After the more acute nephritis has subsided and convalescence promises to become established, iron becomes one of our main reliances, in virtue of its combined hæmatic and diuretic properties. The mistura ferri et ammoniæ acetatis will generally be found to be the best preparation. Quinine is also a remedy of great value in the treatment of convalescence from scarlatinal nephritis. During the height of the inflammation, local treatment is often of great importance. If fever is intense, the pulse full and strong, and if pain and tenderness in the back are pronounced, the abstraction of blood, by leeches or cups, from the loins will often prove beneficial. Large sinapisms and poultices may be applied over the kidneys. Besides assuaging the irritation they tend to promote diuresis and diaphoresis. For obvious reasons, turpentine should not be employed as a counterirritant in these cases. Ascites may occasionally be so excessive that the pressure exerted upon the kidneys interferes with the action of therapeutic agents, and impedes the functional activity of these organs. Paracentesis abdominis, by relieving this compression, will often be followed by copious diuresis and the rapid disappearance of general anasarca. Cases of scarlatinal nephritis which pass into chronic Bright's disease, as rarely happens, will require the treatment appropriate for this condition. During convalescence the usual precautions will be necessary. The treatment of other complications and sequelæ of scarlet fever is not peculiar, and will require no special notice here.

Prophylactic Treatment.—When scarlet fever attacks one member of a household, intelligent prophylaxis can be more successfully practised than is the case with the other specific fevers. All unprotected persons should be rigidly excluded from the part of the house in which the patient is confined. Those entering the sick-room should have no communication with the healthy. Soiled clothing, utensils, excreta should be removed, under cover, by passages and stairways that are not used by others. Soiled linen should not be washed with articles belonging to the unprotected. It should be boiled in separate vessels. As the contagion is especially prone to cling to woollen fabrics, the garments of the attendants should not be of this material. During the fever, daily inunctions will greatly restrict the dissemination of the *contagium* particles. The patient should not put on his regular apparel until the end of the third week. Daily warm baths should, after this, be practised until the sixth week and the completion of desquamation. This usually marks the limit of contagiousness. A number of instances are on record, however, where the disease seemed to spread from cases of scarlatinal nephritis, but it should be remembered that in such cases desquamation is occasionally suspended. Very wide differences of opinion still prevail upon this point. Thompson, who enforces warm bathing, has never known the disease to spread from his patients. Not a few writers consider that protracted isolation of the patient is unnecessary, and that the completion of desquamation need not be waited for, if proper disinfectant inunction and systematic warm bathing be practised. Contagion, however, sometimes occurs after very prolonged intervals, and generally it is better to observe the rule that isolation should be practised until the completion of desquamation. Ashby[90] noted the spread of scarlatina in a ward where an operation had been performed for the removal of pus from the chest of a patient on the forty-ninth day from the beginning of his scarlatina. He concludes: 1. If desquamation is complete, scarlet-fever patients may be discharged at the end of the sixth week, though, in order to secure absolute immunity, it is wiser to delay until the end of the eighth. 2. Cases complicated with nephritis, empyema, otitis, or glandular abscess, should be detained until the cure is complete. 3. While it is important that desquamation should be as complete as possible, the detention of patients beyond the eighth week, in order that the epidermis should be removed from the soles of the feet, etc., is unnecessary. When the patient is prepared to leave the sick-room, he should be bathed and should put on no article of clothing that has in any manner been exposed to the contagion. The sick-room should be dismantled; carpets and hangings should be removed after thorough fumigation of the apartment has been practised; the bedding should be destroyed or steamed; paint and furniture should be washed; the wall-paper should be removed or the walls whitewashed. All articles of wearing apparel or of furniture that cannot be washed should be submitted to the steaming process now available in most large cities, and which is thoroughly effective. Some persons fail to become infected, though unquestionably exposed to the contagion.

Several drugs have been supposed to possess the property, when rightly administered, of protecting from scarlatinal infection those who have been exposed to its influence. Hahnemann attributed such influence to belladonna. The supposed action of this drug was based upon an untenable hypothesis, but remarkable results have been reported as following its administration (Schulte, Massius, Hufeland *et al.*). As, however, scarlatina often fails to spread even when a number of persons have been exposed, the disease exerting its contagious properties most capriciously, the dangers of drawing incorrect conclusions are very great. The most careful observers have about reached the conclusion that belladonna is absolutely without prophylactic value in scarlatina. Nevertheless, there are those who have faith in its efficacy and who always have recourse to it. If it is concluded to try the merits of this drug, the sulphate of atropia may be given in doses of $\frac{1}{200}$ to $\frac{1}{100}$ of a grain daily; or the tincture of belladonna (which is usually employed) may be given. The dose of the tincture should be one drop for each year of the child, administered once or twice daily. It has been claimed that to obtain the desired protection the characteristic effects of belladonna should be produced in the throat and upon the skin. J. Lewis Smith believes that boracic acid, regularly administered, exerts a favorable influence over the course of the disease, and in great measure confers immunity upon those who take it for purposes of prophylaxis. Fordyce Barker[91] claims that salicylic acid possesses prophylactic properties. A few drops of a weak solution in alcohol and warm glycerin should be given once or twice daily.

At one time it was hoped that inoculation with scarlatinous virus might afford a protection from scarlatina similar to that derived from small-pox by inoculation. In the few rather questionable cases in which this has been attempted, the resultant scarlatina appeared to be unmodified. The asserted prevalence of scarlet fever among dogs and cats,[92] and in horses[93] (Peters), has recently again stimulated the hope that protection to the human family may be obtained by a process similar to vaccination. Stickler[94] made a very interesting set of observations, which, however, have not as yet received confirmation. He inoculated rabbits with the nasal secretions of a horse supposed to be suffering from scarlatina. Symptoms of what Stickler considered to be modified scarlatina followed. Later these animals were inoculated with scarlatinal human blood without noticeable result. Again, he inoculated twelve children with matter from "scarlatinous" horses. This was followed

by light eruption, etc. Subsequently these children were inoculated with human scarlatinous blood without effect. Stickler concluded: 1. The subcutaneous injection of scarlatinous virus from horses is without danger. 2. After its injection under the human skin a circumscribed eruption like mild scarlatina appears. 3. After horse-virus inoculation the organism remains resistant to inoculation with scarlatinous virus. It is to be hoped that further investigation will confirm these observations.

I. E. Atkinson.

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SCHINZNACH is a Swiss spa, in Canton Aargau, or Argovie, lying at an elevation of 1,150 feet above the level of the sea. It is protected against the cold winds, yet the climate is somewhat changeable; the average temperature of the summer months is 62.6° F. An analysis of the spring here situated, made by Bolley and Schweizer, gives the following results (Rotureau). A litre of water contains:

	Grammes.
Sodium sulphate	1.2863
Calcium sulphate	0.1571
Potassium sulphate	0.0805
Calcium chloride	0.7144
Magnesium chloride	0.0836
Calcium carbonate	0.1426
Magnesium carbonate	0.0042
Ferrous oxide	0.0011
Silica	0 0128
Aluminium	0.0103
Total	2.4929

The temperature of the water is 86° F. The gases are carbonic acid and sulphuretted hydrogen.

The waters are employed for both drinking and bathing purposes. They are prescribed in the treatment of osteitis and periosteitis, chronic rheumatism, scrofulous affections of the glands, skin, and joints, mercurial and lead poisoning, and various forms of moist and scaly skin eruptions. The season extends from the middle of June to the middle of October. A course of treatment lasts about one month.

T. L. S.

SCHIZOMYCETES AND OTHER VEGETABLE MICRO-PARASITES. Micro-organisms have been found to bear a most important relation to hygiene and to pathology, and the class of organisms most concerned are the *schizomycetes* or *bacteria*. But the *mould fungi*, the *yeast fungi*, and the *protozoa* are also concerned, and have, therefore, been given a place in the following description.

Micro-organisms are present everywhere, in our food and water, in the air, and in the upper layers of the ground. Some of them are of great value, causing putrefaction of dead animals and plants; others cause various fermentations, such as the alcoholic, the acetic acid, etc.; still others cause infectious diseases of animals and plants.

HISTORICAL.*—Although the connection between bacteria on the one hand, and disease, fermentation, and putrefaction on the other hand, has been established only in comparatively recent years, the germ theory had its advocates more than two centuries and a quarter ago. The idea prevalent at that time was that diseases are caused by the putrefaction of humors in the secret recesses of the body. A learned ecclesiastic of the "Society of Jesus," named Athanasius Kircher, found living organisms, invisible to the naked eye, in all sorts of foul matter, in blood, air, water, etc., so that he concluded that if putrefaction is caused by microscopic organisms outside of the body, and if these organisms are found in the blood, etc., they must necessarily cause putrefaction there also. Of course, Kircher was unable to see bacteria with the microscopes in use in his day.† And it matters not what he did see, his observations seemed to substantiate the view that infectious diseases are caused by substances which, introduced into the body, give rise at first to no symptoms, but increase till they bring about disease. The only substances capable of so increasing at the expense of the tissues are living beings, *i.e.*, plants or animals.

First actual observation of micro-organisms.

The first observer who really saw micro-organisms was Anthony van Leeuwenhoek, a private citizen of Delft, in Holland. He spent the latter part of his life in grinding and polishing lenses, and examining surrounding objects of all sorts. Leeuwenhoek (1675) described minute round bodies, rods, threads, and spirals, and spoke of their motion. He examined various sorts of water, the intestines of flies, frogs, doves, chickens, etc., and his own diarrhœal fæces, and found numbers of animalcula, as he called them, varying in form and size and in the character of their motion. In 1683 he observed several different kinds, but one kind was especially abundant in

* Authorities: Löffler, Flügge, and others (see Bibliography at end of article).
† 1657.

the scrapings from between his teeth, notwithstanding previous cleansing, and he made drawings of them. These observations were communicated to the Royal Society of England in a number of letters. Leeuwenhoek made no attempt to assign any importance to these organisms as to any rôle they might play in the economy of nature. He considered it impossible for them to be taken up in the blood, because he imagined that the absorbent vessels were too narrow to allow of the entrance of any such particles, even if they were a thousand times smaller than they really are, and he considered them a thousand times smaller than a grain of sand.

Revival of the vitalistic theory.

But Leeuwenhoek's contemporaries, and those who immediately followed, seized upon the idea of these little worms causing a great number of diseases; even in cases where they were not found they reasoned from analogy that they must be present. Then followed a reaction, and the idea was ridiculed out of existence (1726).

A few men of science, however, still retained the idea of a contagium vivum. Linné held to the idea, as did Plenciz, and the latter deduced logically the connection between Leeuwenhoek's discoveries and contagious diseases, as well as putrefaction. Still all of this was a matter of speculation, and not proven by direct experiment, so that the theory won very few disciples, and was regarded as a vagary till well into the present century.

Thus the rôle that micro-organisms play was often asserted and as often denied; but as matters of curiosity,

First efforts at a classification.

their forms were studied with the microscope with great interest and zeal. The twenty-one different forms that Baron von Gleichen-Russworm observed and pictured in 1778, and the contributions of the many observers from the year 1734 for the next half century, bear evidence of the lively interest, but they led to no important results and may be passed over without further mention. F. O. Müller made an exhaustive study of the various forms of micro-organisms in 1786, and pictured many of those known to us at the present day. The question, however, as to the origin of these micro-organisms seems to have been of greater interest in those days than the question as to what function, if any, they performed. The earlier observers satisfied themselves with studying their morphology and attempting to classify the micro-organisms, but their biology was merely a matter of surmise, which has had to suffer many alterations in the light of the experiments of recent years. Another question, too, which attracted

Generatio aequivoca.

the liveliest interest was as to the source of these minute beings, and the theory of spontaneous generation, which had been overthrown for insects, again occupied the most serious attention of the scientific world. It would be aside from the purpose of this article to enter into a detailed account of the discussion of generatio aequivoca, but the following experiments, which overthrew it, shed a flood of light upon a number of important points.

Charles Bonnet attacked the idea of spontaneous generation, upon theoretical grounds, in 1762, and Lazarus

Beginning of scientific experiments.

Spallanzani showed the correctness of Bonnet's views by experiments in 1769. Spallanzani convinced himself that in infusions exposed to the air there was always a development of animalcula, as they were then supposed to be. He then heated his vessels, and poured boiled infusions into them, and sealed them; but in spite of that some of the infusions became foul. He reasoned correctly from this, that the air contained in the vessels must contain the organisms of putrefaction. So in his following experiments he sealed the vessels containing the infusions and kept them an hour in boiling water, and all of the infusions remained sterile. Franz Schulze showed, in 1836, that the air could have access to sterilized infusions without causing putrefaction, if it were sterilized, *i.e.*, passed through sulphuric acid; and Schwann effected the same thing, in 1837, by passing the air first through molten metal, or by heating it with a spirit-lamp. Schroeder and von Dusch then showed, in 1854, that if the air was filtered through cotton wool, it was incapable of producing putrefaction. H. Hoffmann showed, in 1860, that it was not even necessary to pass the air through cotton, but that, if the neck of the flask were drawn out and bent over, there was no putrefaction in the previously boiled contents. Chevreul and Pasteur made the same observation in 1861, independently of Hoffmann. Van der Broek had shown, in 1857, that if grape-juice, blood, or urine were caught in sterilized vessels, with proper precautions against contamination from the air, they could be preserved indefinitely, and this was substantiated by a number of observers, beginning with Pasteur, in 1863. But a certain percentage of the experiments with infusions which had been boiled and protected from subsequent contamination failed, and a series of experiments of Bastian, in 1873, in which he took an infusion of turnips and added bits of cheese, seemed to indicate that there must be spontaneous generation, for after boiling his mixture ten minutes there was still a growth of organisms after three days' time. But Ferdinand Cohn showed, in 1875, that in infusions of hay, in cheese, and in all fluids which showed a growth of organisms after having been subjected to the boiling temperature and protected from subsequent contamination, there were micro-organisms which possessed the power of assuming a more resistant form. Bonnet had already, in 1762, suggested the possibility of there being organisms capable of such resistance, and Pasteur found he could only sterilize milk at a temperature of 110° C. (230° F.). Schroeder had met with the same difficulty. I shall reserve the discussion of this very important property of micro-organisms, viz., the formation of spores, till later on. The question of spontaneous generation was thus finally settled in the negative.

But, in the meantime, the study of the morphology of micro-organisms was pursued with great energy.

Further efforts at classification.

Christian Gottfried Ehrenberg published a systematic account of bacteria in 1838. His observations were made with the improved microscope of that time, and constitute a new era in the study. Ehrenberg, however, erroneously assigned them a place in the animal kingdom on account of their undoubted independent motion, and also on account of the flagella which he saw on many forms; and finally, he thought he saw eggs and granules, and the process of self-division. Ehrenberg made experiments in feeding bacteria with carmine, and as he found the particles taken up and lodged in various parts of the organisms, he classified them under the polygastrica. Even those organisms which did not take up the carmine granules he regarded as belonging to this group. He called the genus "The Animalcula of Infusion." Ehrenberg was fully aware that his classification was imperfect, and Dujardin's attempted improvement was also equally unreliable. These were, however, steps in the right direction, for, with the exception of Müller's classification, which was made with a microscope greatly inferior to that of Ehrenberg, there was no previous classification. The observations during the next few years of the strong analogy between the algæ and bacteria, led many observers to doubt whether Ehrenberg's idea that the latter belonged to the animal kingdom was correct, and Perty expressed the opinion, in 1852, that a part of them belonged to the animal, and a part to the vegetable, kingdom. The final blow to Ehrenberg's classification was

Cohn's classification.

given, in 1854, by Ferdinand Cohn, in his work on the life-history of the microscopic algæ and fungi. Cohn established the fact that a hopeless confusion existed as to all the forms which had been observed; that the observers had worked with different powers of the microscope, or made their observations loosely; and, finally, had mixed up the young with the matured cells, so that there was the greatest complication. He, therefore, selected the bacterium termo of Dujardin, or the vibrio lineola of Ehrenberg, which is found in all sorts of infusions undergoing putrefaction, and made a thorough, systematic study of this class of organisms. He made a special family out of it, which he called *zooglœa*, and established a very close relationship to the family *oscillaria*, a distinctly vege-

table class belonging to the algæ. The question was thus settled for the vibrio lineola, but Cohn reserved his decision in regard to the other vibrios. Other authors also inclined to the opinion that all these lower forms belonged to the vegetable kingdom. Naegeli had already, in 1849, emphasized the resemblance between the algæ with color and the colorless algæ, and finally made a separate class of the latter, because he observed that they were unable to derive their nourishment from inorganic materials. The former class, algæ with color, are able to subsist upon simple CO_2, NH_3, and H_2O, with certain dissolved salts, just as are the higher plants; the colorless algæ, however, require elaborated pabulum, as is the case with animals, and are not able to liberate oxygen. He consequently considered all the forms which had no chlorophyll as belonging to the fungi, and used the name *schizomycetes* for the whole group of bacteria, vibrios, spirilla, sarcinæ, mother of vinegar, and a specific organism which Cornalia had discovered as causing a disease in silkworms, called *nosema bombycis*. But Naegeli left it an open question whether they belonged to the vegetable or to the animal kingdom. Nevertheless, he showed that they all had certain very distinctive qualities in common, and, as already stated, he and Cohn emphasized the near resemblance through the algæ to the vegetable kingdom.

Naegeli's classification.

As far, however, as the establishment of specific groups of schizomycetes was concerned, there was nothing more determined up to this time (1857) than had been already done by Müller in 1786.

As already stated, the physiological properties of the schizomycetes were also studied in the meantime, with as much success, if not more, than the morphology and classification. Omitting observations which tended more to arouse interest than to advance our knowledge in regard to the rôle played by micro-organisms in various chemical processes and diseases, the first scientific proof that organisms do play such a rôle was made by Cagniard Latour and Schwann, independently, in 1837. These authors observed the growth and reproduction of the organism which had been seen by Leeuwenhoek, and which Turpin had called torula cerevisiæ, in the fermentation of beer and wine, and showed that its growth and reproduction caused the fermentation. Although the belief in the causal connection between organism and disease was strengthened, it was not proved by these experiments. But it was not long before the necessary proof was given, at least for one disease, for in the same year Bassi discovered that a disease of silkworms was due to a fungus, the spores of which covered the bodies of the worms in the form of a white powder, and a trace of this powder produced the disease upon healthy worms.

Study of physiological properties.

Jacob Henle was convinced of the connection between micro-organisms and disease by a careful consideration of the above facts. The plausibility, theoretically, of a belief in a contagium vivum in infectious diseases also forced him to this conviction, and the weight of the opinion of this great authority contributed much to arouse interest in this line of investigation. Henle was not led to change his opinion by not finding organisms in the tissues in various contagious diseases, for he contended rightly that at that time (1840) there were no means known by which it was possible to distinguish between various cells, or cell-nuclei, or nucleoli, and micro-organisms. Nor did he consider the presence of organisms alone sufficient proof of their causal relation, but postulated conditions which we shall presently see have been fulfilled to the letter. The conditions were constant presence, isolation, and proof of the contagiousness of the isolated organisms (by inoculation). When these conditions are fulfilled there can surely be no room for doubt. Similar conclusions were reached by deductive reasoning by J. K. Mitchell, independently, at about the same period.

Henle's deductions.

The next several years were spent in ceaseless activity, by a host of workers, in seeking organisms in various diseases. Bassi's discovery and Henle's deductions inspired the liveliest interest in this line of research; but as the methods at that time employed were very crude as compared with the methods of the present day, much of the work has since been shown to be of little or no worth. The discovery of the sarcina ventriculi by the Goodsir Brothers belongs to this era, and attracted the widest attention.

The epidemic of cholera, which appeared for the second time in 1849–50, in Europe, also awakened great activity in the search for organisms, for it was considered very likely that this disease is caused by a living contagium. The observations on cholera at that time have, however, been found to be erroneous, for the same micro-organisms which were then observed in the excretions of cholera patients were afterward found in a variety of other diseases, and even in fæces from healthy individuals. Bits of food in the cholera stools were also mistaken for micro-organisms. But aside from these results, which were either erroneous or not sufficiently convincing, a great number of diseases of insects, and of the cereals and potatoes, were proven to depend upon micro-parasites, and the same was also shown for favus and several other diseases of the skin. Pollender, too, about this time (1849), observed the anthrax bacilli in blood, and he was followed by Davaine the next year. But there was more zeal than judgment displayed by many workers at this time, and progress was retarded, especially by the writings of Hallier, who thought he had discovered the specific organism for a great many diseases.

Cholera in 1849 and 1850.

The next important epoch was ushered in by Pasteur's discovery of the rôle played by micro-organisms in various sorts of fermentation, in 1857. Cagniard Latour and Schwann, it will be remembered, had already established the relation between organisms and the alcoholic fermentation, but Pasteur deserves the credit of finally establishing that lactic-acid fermentation, butyric-acid fermentation, acetic-acid fermentation, etc., are all caused by micro-organisms, which not only differ in their physiological workings, but are well characterized by morphological and biological peculiarities. In this connection Pasteur also made the discovery of micro-organisms not capable of growth in free oxygen, and assigned to them the names *anaërobic* micro-organisms, to distinguish them from the *aërobic*, or those requiring the presence of free oxygen. Pasteur, moreover, discovered that certain organisms were capable of growing either with or without free oxygen, and these he called *facultative anaërobic* organisms. He considered all the micro-organisms of putrefaction as anaërobic, but offered proof only in a few cases. Pasteur next studied, more exactly than had as yet been done, the products obtained by vinous and acetic-acid fermentation. After having established the important rôle played by micro-organisms in so many processes in the economy of nature, Pasteur rightly concluded that they are necessary for the life of plants and animals, for without their agency the higher plants, incapable of feeding upon the complex molecules of dead animals and plants, would die if dead bodies did not undergo a putrefactive disintegration through the instrumentality of micro-organisms. Thus the germ theory was established; and although there have been, and still are, points about which all authorities do not agree, no one at the present day can have a reasonable doubt of the existence of micro-organisms, nor that they are an important element in nature.

Pasteur's work.

CLASSIFICATION.*—The *mycetes*, or *fungi*, embrace all the vegetable micro-organisms which are known to cause disease, fermentation, and putrefaction. They are *cryptogamic* plants, *i.e.*, they have no blossoms, but many of them reproduce by means of spores, small, highly refractive, oval or spherical cells, which are not as readily killed as the vegetative cells. The *phanerogamic* plants, on the other hand, embrace all the ordinary flowering plants and reproduce by means of seed. The *cryptogamæ*

* Leunis: Synopsis der Pflanzenkunde, 3. Abth. Kryptogamen, bearb. von Frank —— and Flügge, as above.

are divided into *C. vasculares*, or those with leaves and stems, *e.g.*, ferns, etc.; and *C. cellulares*, those without leaves and stems. *C. cellulares* are divided into the *mosses*, *algæ*, *lichens*, and *fungi*. The *algæ*, *lichens*, and *fungi* constitute the *thallophyta*, or plants forming a *thallus*, to be described further on.

The *mycetes*, or *fungi*, are divided into seven orders—*ascomycetes*, *basidiomycetes*, *zygomycetes*, *phycomycetes*, *blastomycetes*, *schizomycetes*, and *myxomycetes*. The first four orders have many points in common, and may be conveniently described under the collective name *mould fungi*, as they cause the moulding of bread, cheese, etc. The *blastomycetes* contain no pathogenic micro-organisms, but the family *saccharomycetes*, belonging to this order, causes alcoholic fermentation. The *schizomycetes*, or *bacteria*, are of more interest than all the others.

Beside the botanical classification it becomes necessary to divide micro-organisms into *parasites*, or those capable of growing upon living plants and animals, and *saprophytes*, or those growing upon dead plant or animal matter. Pathogenic micro-organisms must, of course, be parasites, but many of them grow as saprophytes also, and these are called *facultative parasites*. Therefore, all the pathogenic micro-organisms which are grown in cultures are facultative parasites.

Mould fungi.

A. The *mould fungi* consist of microscopic cells with membrane and cell-contents; the former consisting of a substance resembling cellulose, but differing from it in not giving the violet iodine reaction. The cell-contents consist of protoplasm possessing no demonstrable nucleus, no starch granules, and no chlorophyll, but often having vacuoles, oil-drops, various coloring matters, and, occasionally, crystals of oxalate of calcium. These crystals are very often found upon the outer surface of the cell-membrane. The cells are in the shape of threads called *hyphæ*. The hyphæ generally have transverse cell-walls, and are nearly always branching, the branches growing out from the side of the cell, or each cell sending out two prolongations in the process of growth. The hyphæ are either fruit-bearers or *mycelia*, and whether consisting of one thread or more, or whether they are all mycelia or all fruit-bearers, bear the collective name *thallus*. The mycelia form the vegetative part, the fruit-bearers form the reproductive part of the thallus. The thallus is usually composed of a tangled mass of hyphæ, but occasionally a mycelium assumes, secondarily, a thick fleshy form, the so-called *sclerotium*. The sclerotium has a cortical and a medullary portion, and is only capable of sending out fruit-bearers when exposed for a long time to favorable conditions of temperature and moisture.

The mycelia are capable of penetrating into the cells as well as into the intercellular tissue of dead plant and animal matter. But some of them are not restricted to dead animal and vegetable matter. The mycelia of the latter fungi either penetrate directly the cell-walls of living cells, or they send out short suckers, *haustoria*, which press their way through the cell-membrane. Even bones and teeth are sometimes destroyed by fungi, and their tissues are then found to be crowded with masses of mycelia.

Fructification in the mould fungi.

Reproduction takes place, as already stated, by means of spores, which afterward germinate, sending out one or more hyphæ. Spores are formed in several ways:

(a) Intercalary Spore-formation. Some of the cells of the hyphæ in the process of growth change directly into spores or into mother-cells.

(b) Acrogenic Spore-formation. The ends of the fruit-bearing hyphæ are divided off by a transverse membrane, and perform the function of spores. The thin stems of the fruit-bearers are called *basidia*, and in some cases fine branches connect the spores to the end of a basidium. The fine branches are called *sterigmata*.

Liberation of spores.

There may be one or more spores given off from a basidium. In the latter case the spores form one after another in a row, or in several parallel rows. The spores themselves are usually called *conidia*. They are also known as *basidiospores* or *acrospores*. The separation of the conidia from the basidium takes place in one of three ways:

Ejaculation.

First, the fruit-bearer simply falls to pieces and liberates them; second, the part of the basidium or sterigma immediately behind the spore dies and allows them to fall off; third, the spores may be ejaculated from the end of a tubular basidium as follows: The membrane of the basidium is very elastic, and as the spore approaches maturity this membrane becomes stretched by the absorption of water into the cell to such an extent that it bursts at the weakest spot, which is the zone just where the spore joins the basidium. As soon as the rupture takes place, the elastic cell-membrane contracts and squirts out the contents of the cell. The basidia may grow out from the inner wall of a hollow organ of fructification; in this case they cover the entire inner surface of the capsule, and give off numberless spores.

(c) Endogenic Spore-formation. This takes place in the interior of mother-cells, or *sporangia*. The spores are liberated from the sporangia by the bursting of the latter, or by its membrane becoming dissolved in water, or by ejaculation. The spores have no distinct membrane. Tubular or club-shaped sporangia are called *asci*, and the spores are called *ascospores;* these are generally eight in number to each ascus. The asci are often enclosed in spherical or flask-shaped organs, called *perithecia*. Some of the endogenic spores are liberated under water and have cilia, and are endowed with motion. These are called wandering spores. They finally come to rest and gradually form a cell-membrane, and may then germinate as other spores.

(d) Formation of Zygospores and of Oöspores. Fungus spores often result from copulation. The copulation may be asexual, in which case two mycelia of apparently the same sort send out club-shaped processes which unite. The resulting spores are then called *zygospores*. But in some cases there is a male and a female organ. One mycelium sends out a long, tubular, or club-shaped male organ, called an *antheridium*, to unite with a spherical female organ, or *oögonium*, of a different mycelium. These are called *oöspores*. They are spherical and provided with a membrane of cellulose.

Oöspores and zygospores are generally perennial, requiring a period of rest before they can germinate. They are usually simple, but may be compounded of a number of cells of various shapes. They are either spherical, oval, or occasionally rod-shaped. The cell-membrane is composed of a colored episporium and a delicate, colorless endosporium, which encloses the protoplasm and often contains oil-drops. The spores may develop into sporangia, or they may send out mycelia.

Pleomorphism in the mould fungi.

All these methods of forming spores may take place coincidently or alternately on the same plant. Furthermore, the same fungus may require entirely different nutrition in successive generations. It may act as a parasite to a certain higher organism in one generation, but require an entirely different host in the next. Thus there is quite a wide range of pleomorphism in the broad sense in these fungi.

The *ascomycetes* are the only order that forms asci, and they only do so at the summit of their development. Some of them are parasites, but do not form asci till after the invaded plant or animal is dead. The asci are formed directly on the mycelium only in the lower members of this order. A very large number of fungi belong to this order, but only three of them concern us at present—*Aspergillus*, *Penicillium*, and *Oidium*.

Aspergilli.

The true Aspergilli usually form conidia. The fruit-bearers are long and swollen at the ends into spherical or club-shaped vesicles. The spores are attached to the vesicles by means of a mass of radiating sterigmata (Fig. 3388), which are in some cases branched and in others unbranched. The spores vary from 1 μ to 6 μ in diameter.

Occasionally there is a formation of asci inside of small spherical perithecia, which are about one millimetre in diameter, and have each a separate membrane;

the latter is usually colored and has hair-like projections on the surface. This membrane bursts at maturity. In the *eurotium-aspergillus* the perithecium is preceded by what is possibly a process of sexual copulation, as follows: Several fine branches are first given off from a mycelium; these branches then twist together, forming a sort of corkscrew; this is the so-called *ascogonium*, which represents the female organ. After the formation of the ascogonium several branches grow out from the base, and finally blend together to form the membrane of the perithecium. These secondary branches which form the perithecium are called *pollinodia*, and one of them, while they are still separate, lays itself upon the last turn of the screw-like ascogonium and an intermixture of contents takes place (see Fig. 3389). The pollinodia are looked upon as the male organ.

FIG. 3388.* — Fruit-bearer of a True Aspergillus, showing the Swollen End with Numbers of Spore-bearing Sterigmata. × 180.

The formation of delicate perithecia is met with in the so-called eurotium-aspergillus, as already stated, and this distinguishes the latter from the true aspergilli, which form sclerotia. The thick sclerotium of the true aspergillus remains inert as long as it is dry, but in the presence of moisture it sends out threads which afterward form asci. For the formation of perithecia the very best nutrition is required.

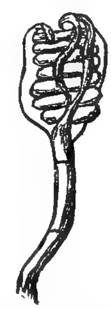

FIG. 3389.—Formation of a Perithecium by Copulation. The Coiled Ascogonium surrounded by the Pollinodia. × 250.

THE PATHOGENIC MOULD FUNGI.—The lesions produced by the pathogenic mould fungi differ from those produced by the pathogenic bacteria. The tendency of the latter is to cause a general infection of all the organs and tissues of the body. Even where the lesion is at first local, the organisms usually get into the blood and are conveyed to all parts of the body. The mould fungi, on the other hand, become lodged in the internal organs, especially in the kidneys, and the mycelia grow out and form distinct foci.

The Pathogenic Aspergilli.—Three species of *aspergilli* have pathogenic properties when injected into the veins of various animals. Inhalations of the spores produce mycosis in the lungs of birds. Animals have been found suffering from an infection without intentional inoculation. The aspergilli are widely distributed, and are found upon mouldy bread, etc.

Aspergillus fumigatus. — Greenish. Conidia-bearers short and swollen into hemispheres, 8–12 μ in diameter, very thickly set with awl-shaped sterigmata. Conidia round, smooth, show no membrane, and are generally colorless, 2.5–3 μ in diameter. Sclerotia are unknown. Grows best at 37°–40° C. Possesses more powerful pathogenic properties than the other two.

Aspergillus niger.—Brownish-black. Fruit-bearers are exactly globular. Sterigmata, 20–100 μ long and branching. Conidia round and brownish-black at maturity, and 3.5–5 μ in diameter. Sclerotia size of rape-seed, and brownish-red. Optimum temperature about 35° C. Does not seem to have any very great malignant power.

Aspergillus flavus or *flavescens.* — Green or greenish-brown. Conidia yellow or brown, with a finely nodular surface, 5–7 μ in diameter. Sclerotia very small and black. Grows best at about 28° C. Stands next to *A. fumigatus* in *pathogenic power*.

The most common of all fungi is the *Penicillium glaucum.* In the family to which this belongs, *penicillium*,

Penicillium.

the conidian fructification is alone met with, except under very extraordinary conditions of nutrition. In the latter case the penicillium occasionally produces a small protuberance, about the size of a grain of sand, upon a mycelium, and this protuberance behaves like a thick-walled sclerotium. Still, as a rule, the fruit-hyphæ are branched, and have a cluster of conidia upon the end of each branch. As is shown in the accompanying cut (Fig. 3390), the conidia are formed in rows upon the finger-like terminal branches of the hyphæ.

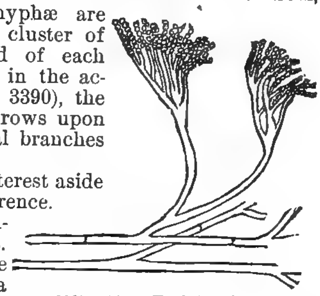

FIG. 3390.—Two Fruit-bearing Hyphæ of a Penicillium. × 170.

Penicillium has no interest aside from its frequent occurrence.

Oidium, Mildew.

The *Oidia* form summer and winter spores. The former are simple conidia separated in a row from the ends of the long, straight mycelia. The winter spores are formed in perithecia, which develop secondarily upon the same mycelia from which the summer spores were given off. The winter spores require a state of rest, *i.e.*, through the winter, before they germinate. The oidia cause the so-called "mildew." A scurf of the comb and gills of poultry, and favus of mice, and perhaps favus and herpes tonsurans in the human being, are caused by the growth of oidia.

FIG. 3391.—Mucor, showing Four Sporangia. × 140.

Some of the members of the Basidiomycetes and Phycomycetes are parasites of plants, but as none of them have been found to cause disease in animals they may be omitted without description.

The Zygomycetes order has among its families the *Mucorineæ*, to which the mucors belong. In the Mucorineæ

Mucors.

the organs of copulation blend to form a zygospore. Spores are also formed without copulation in the interior of sporangia (Fig. 3391), by the division of the protoplasm into small unicellular spores (Fig. 3392), which are liberated by the dissolution of the membrane of the sporangium in water. This membrane is at first colorless, but afterward becomes black. The fruit-bearing hyphæ grow up perpendicularly.

FIG. 3392.—A Sporangium Imagined in Vertical Section, filled with Spores. × 1240.

Pathogenic Mucors.—Two mucors have pathogenic properties when injected into the blood. Rabbits die in forty-eight to seventy-two hours after injections of the spores of *M. rhizopodiformis* and of *M. corymbifer.* The mycelia are found upon post-mortem examination chiefly in the kidneys, but also in the mesenteric glands and Peyer's patches.

B. *The Saccharomycetes*, belonging to the order Blastomycetes, grow by

Yeast fungi.

budding. The parent cell becomes enlarged at some point into a protuberance which grows larger, and either separates or remains attached, and becomes in turn a mother-cell (see Fig. 3393, 6). The formation of ascospores has also been observed.

No pathogenic saccharomycetes have as yet been discovered, but they are of great interest because many of them cause the alcoholic fermentation of sugar. This function, however, is not peculiar to the saccharomycetes, for mucor racemosus also causes the same fermentation. It is even probable that all the saccharomycetes are merely a form of mould fungus, since this same mucor racemosus assumes the budding growth if it is immersed in a solution of sugar. The CO_2 which is liberated in the fermentation buoys the mucor, which has for the time become a budding fungus, up to the surface, where it again sends out hyphæ.

C. *The Schizomycetes*, or *Bacteria*, are very minute uni-

* The accompanying figures were not drawn from actual observation with the microscope, except Figs. 3395 and 3396 (p. 333). Some of them are modified copies from Flügge's Die Micro-organismen (see p. 343).

cellular organisms. They play an exceedingly important rôle in pathology and hygiene. Some members of this group cause many of the most terrible maladies of animals and plants, they constitute the contagium vivum of many infectious diseases; others are of the greatest use in preparing dead vegetable and animal matter for assimilation by the higher plants; others, again, are concerned in fermentation.

Bacteria.

A bacterium consists of protoplasm enveloped in a cell-membrane. The cell is generally colorless; in some rare species it contains chlorophyll or other coloring matter. The protoplasm may also contain minute granules of sulphur, and sometimes refractive oily particles. It is sometimes granular. Some bacteria give the blue iodine reaction, which is especially marked just before the formation of spores. Under unfavorable conditions of growth the protoplasm becomes cloudy and breaks up into granules. The cells have no nuclei. The cell-membrane is sometimes colored, and sometimes is surrounded by a gelatinous envelope or capsule, which can be occasionally brought out by staining.

FIG. 3393.—1, Staphylococci. 2, Streptococci, showing in two places larger forms, to signify arthrospores. 3, Micrococci tetrageni. 4, Sarcinæ. 5, Diplococci. The four diplococci to the right, colored black throughout, are called biscuit-shaped (see Chicken Cholera and Gonorrhœa, below), and are also regarded by many as bacilli. 6, Saccharomycetes.

Classification of bacteria.

It is sufficient for our purpose to divide bacteria into *micrococci*, *bacilli*, and *spirilla*. Micrococci are spherical or slightly oval, and bacilli are rod-shaped. It is evident that the individual bacteria may lie separated from one another after cell division, or they may hang together and form chains, threads, irregular clumps, etc. Now, an organism which grows so as to form chains always retains this tendency; it does not form chains in one generation and clumps in another. This property of organisms has been used as an important means of diagnosis, especially of the cocci. Micrococci which always tend to form chains are called *streptococci;* those forming irregular clumps *staphylococci.* Micrococci which grow so as to form tetrads are called *tetragoni.* If they hang together in all three dimensions of space, they resemble packets bound tightly around with two cords at right angles, and are called *sarcinæ.*

Although bacilli also form chains and clumps, no such distinction is made as in the micrococci, except that bacilli in chains are sometimes called leptothrix. Very short bacilli were formerly called bacteria, but the latter name has come to be universally adopted for the schizomycetes in general. Some of the distinctions of the varieties of bacteria are very slight, and are only apparent to the practised eye. Thus, *clostridia* (Fig. 3394, 1) are bacilli of a spindle shape, and bacilli with a constriction in the middle are called dumb-bell or figure-of-8 shaped (Fig. 3394, 3), and rods with parallel sides may have rounded, square, or even concave, ends. Bacilli that are curved on the long axis are called *commas*, or *comma-bacilli* (Fig. 3394, 4), and a chain of them constitutes a *spirobacterium* or *spirillum.* But there are also spirilla, or long spiral threads, which show no division into commas (Fig. 3394, 4). The bacteria never branch as do the mycelia of the mould fungi.

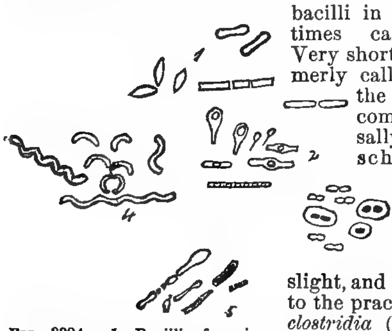

FIG. 3394.—1, Bacilli of various shapes. 2, Bacilli in the process of forming spores. 3, Bacilli enclosed in capsules and figure-of-8 bacilli. 4, Comma bacilli and spirilla. 5, Forms of involution. × 700.

The schizomycetes multiply by fission, the cells simply grow larger and divide, and afterward separate or hang together as already explained. Micrococci show no variation, they simply form micrococci from one generation to the next, but the other members of this order are subject to quite decided changes of form, owing to various conditions.

Involution.

Under favorable conditions bacteria continue to reproduce vegetative cells indefinitely, and under unfavorable conditions they either form spores or undergo a retrograde metamorphosis. In the latter case they degenerate into what is known as forms of involution (Fig. 3394, 5). The cells become swollen and have irregular protuberances on them, and are often so distorted as to bear no resemblance to the normal cells.

Formation of spores in bacilli.

The formation of spores of bacteria may be properly regarded as a metamorphosis; it is a simple transformation of a vegetative into a germinative cell under conditions unfavorable to growth. It is a provision for the perpetuation of the species, and occurs when the organism has nearly exhausted its supply of nutrition, or poisoned it with products of its growth, etc. It takes place whenever the organism is threatened with extinction. The fungi, on the other hand, form spores under the most favorable conditions, even requiring an abundant supply of nutrition, etc., for their production. Indeed, the life-history of the fungi is incomplete without the formation of spores. But it is comparatively rare in the bacteria, and all the conditions which tend to bring it about are not yet known. It is not the result of copulation.

Characteristics of spores.

Bacteria are said to form two kinds of spores, *endogenic* spores and *arthrospores.* Both kinds survive the action of agents which would kill vegetative cells, but endogenic spores are more resistant than arthrospores. The latter have been but little studied. They possibly are present in all sorts of bacteria, and are generally not distinguishable in appearance from the other cells, though sometimes they are larger and have a higher refractive index, etc. (see Fig. 3393, 2). The term, therefore, merely means that certain individual bacteria have a higher resisting power than the ordinary vegetative cells, but are not as resistant as endogenic spores, and may or may not be distinguishable under the microscope. But the endogenic spores have very marked characteristics. They are very highly refractive, and appear as round or oval bodies lying in and among the vegetative cells (see Fig. 3394, 2). Their resisting power is very great; the endogenic spores of some bacteria survive even the temperature of boiling water several minutes (see p. 325). As we shall see presently, the vegetative cells are readily stained with aniline dyes, but the endogenic spores are not stained under ordinary circumstances. They are only found in bacilli, and possibly in spiro-bacteria. Micrococci are restricted to the formation of arthrospores. In the following the word spore is meant to refer to endogenic spores.

Germination of the spores of bacilli.

Spores represent a state of suspended activity, and they may remain inactive for months and years, till they are removed from the medium in which they have been formed and are placed under proper conditions for germination. Under suitable conditions of temperature, moisture, etc., the clear globular mass in which each spore is embedded becomes ovoid and gradually elongates into a rod, the spore in the meantime becoming less and less refractive, and finally disappearing (Koch). Or, the spore swells and loses its refractive power, its dark contour, and its transparent capsule. Germination then takes place, either in the direction of the long axis of the spore or at right angles to it. In the latter case there appears a dark crescentic shadow at each pole of the spore, and a papilla grows out from one side and increases in length till it becomes a rod. In the other case, the cell-membrane of the spore becomes uniformly thickened, and the bacillus is liberated by growing out and breaking through at one of the poles (Prazmowski and Brefeld). The membrane

of the spore which has been thus abandoned by the bacillus remains for some time lying near the latter.

Independent motion of bacilli and spiro-bacteria, and the formation of zoöglœa.

Many of the bacilli and spiro-bacteria are endowed with the power of independent motion; the micrococci have no motion of their own. If bacteria are examined in water, there is always more or less agitation, due to unintentional movement of the microscope, and currents caused by evaporation, etc., but this is the so-called Brunonian molecular motion, and has nothing to do with the indepeudent motion of some bacteria. Bacilli thus endowed dart about in all directions, with a wriggling motion, always end foremost, never sideways. The spirilla have also a twisting motion. The motion in some cases is due to the vibration of a flagellum or fine thread at the ends of the rods. When bacteria accumulate into masses they cease to move, and the masses are called *zoöglœa.*

Colonies of bacteria.

Although the individual bacteria are so minute, their multiplication is so rapid that, starting from an invisible number, they may form macroscopic masses in one or two days in solid media. These masses, whether they are macroscopic or microscopic, are called *colonies*, and we shall see farther on that they are characterized in each species by color, contour, etc.

CONDITIONS OF THE GROWTH OF ORGANISMS.—Some of the conditions of growth have been already mentioned, but in order to understand the laws of nutrition more clearly, the following chemical analysis is not without value. The analyses of the mould fungi and saccharomycetes have been reserved for this place, in order to compare them with that of the schizomycetes.

	UNDRIED.	WATER DRIVEN OFF.			
	Water.	Albumen.	Cellulose.	Fat.	Ash.
	Per cent.	Per cent.	Per cent.		
Mould Fungi	88	29	50	Appreciable.	Appreciable.
Saccharomycetes	40–80	47	37	Appreciable.	Appreciable.
Schizomycetes	83–85	84–87	None.	Appreciable.	Appreciable.

The composition of the ash is as follows:

	Potash.	Soda.	Lime.	Magnesia.	Oxide of iron.	Phosphoric acid.	Silicic acid.	Hydrochloric acid.	Sulphuric acid.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.			
Mould Fungi	50	1.5	1	2	1	30	Small amount.	Small amount.	Variable.
Saccharomycetes	28–39	....	1–4	6–8	....	53–59	Sometimes a trace.	....	....
Schizomycetes.*									

* Probably the same as for the Saccharomycetes.

The above analysis of the ash of the mould fungi is really the mean of a number of analyses of the ash of the higher fungi, but is probably approximately correct for the lower fungi.

From the foregoing it will be seen that water enters largely into the composition of all three classes. The schizomycetes contain the largest amount of albumen, and the mould fungi the least. The mould fungi have the largest amount of cellulose, and the schizomycetes none at all. Potassium and phosphoric acid are the principal ingredients of the ash of all three.

It is evident that these organisms require carbon, nitrogen, oxygen, and hydrogen in some form.

Sources of carbon.

As bacteria are, with very rare exceptions, devoid of chlorophyll, they cannot utilize the carbon in the CO_2 of the air, and are therefore compelled to have more elaborate molecules, such as are supplied by plants and animals. Double molecules of carbon, or C in combination with N or O, are unsuited, but C in combination with H (CH_3 and CH_2) are readily assimilated. Thus the sugars constitute a very good source of carbon, whereas cyanogen cannot be used.

Sources of nitrogen.

Nitrogen is, preferably, derived from albuminous matter and peptone, but NH_2 and NH compounds may also serve as a source. Nitrates are also available, but cyanogen is not.

Sources of hydrogen and oxygen.

The hydrogen and oxygen are supplied by the nitrogen and carbon compounds, and also by water.

The above is true for the mould fungi, and saccharomycetes as well, except that the latter are not capable of assimilating the ammonium salts or the nitrates. Furthermore, the mould fungi require free oxygen for their normal growth. The saccharomycetes are capable of growing without it, they are facultative anaërobic organisms. The schizomycetes, as we have seen, vary in their behavior toward oxygen; some of them are aërobic, some anaërobic, some both. The mould fungi grow best in slightly acid media, whereas the other two classes prefer neutral or slightly alkaline substances; some of the latter refuse to grow in the presence of even a trace of free acid.

Very striking behavior of bacteria derived from water.

The water organisms seem to defy all the laws of nutrition above laid down. Other bacteria require at least an appreciable amount of nitrogen and carbon compounds and salts, whereas the aquatic cocci and bacilli find nutrition enough for active growth in freshly distilled water. Distilled water has been used, in fact, to cultivate them through many successive generations.

Influence of temperature, etc.

Of physical conditions temperature plays the most important part. Roughly speaking, temperatures of 30° to 35° C. (86° to 95° F.) are most favorable to active cell multiplication, and also for the formation of spores. Below 18° C. (64.4° F.) growth is retarded. Some organisms refuse to grow at the lower temperatures, and others refuse to grow at the higher; others, again, vegetate very well at temperatures below 18° C. (64.4° F.), so that a general statement is hardly permissible. The vegetative cells are killed in a few minutes by temperatures above 60° C. (140° F.) (Sternberg *et al.*). The presence or absence of light seems to make no difference, except that direct sunlight kills the spores of anthrax in a few hours (Arloing). Pressure of 600 atmospheres continued for twenty-four hours had no effect upon anthrax bacilli, and yeast stood a pressure of 300 to 400 atmospheres; putrefaction did not cease under a pressure of 350 to 500 atmospheres (Certes). Electricity has no effect except very powerful constant currents, which check the growth of organisms (Cohn and Mendelssohn). Mechanical agitation has been repeatedly tried, but the results of the experiments do not agree. It would seem, however, that rest is conducive to growth, for the peculiar class of aquatic bacteria multiply with enormous rapidity in stagnant water (Cramer), but whether this is due to stagnation alone or to other causes is not known.

A great many chemical substances have been found to kill micro-organisms, but the most valuable one for disinfecting purposes is corrosive sublimate (Koch), when it can be applied. In the laboratory a 0.1 per cent. solution is employed to disinfect cultures when they are to be destroyed, and for similar purposes; but a very much more dilute solution is sufficient, if allowed to act for an hour or so. Aqueous solutions of chlorine, bromine, iodine, carbolic acid, osmic acid, permanganate of potash, and bleaching powder, all act as disinfectants, but the solutions have to be much more con-

centrated than solutions of corrosive sublimate. For a complete discussion of disinfectants and germicides see under the headings Disinfectants and Germicides.

Media Employed for Bacterial Cultures.—From the above consideration of the conditions of growth, it becomes apparent that suitable media must contain soluble albumen and certain salts, and, moreover, abundance of water. Three substances have come into universal acceptance as fulfilling all these conditions: Infusions of flesh, boiled potatoes, and blood-serum. Beef-broth is most generally used, and is prepared as follows:

Preparation of nutrient gelatine and agar.

A half of a kilogramme of lean beef is freed of all tendons, etc., and chopped up fine in a sausage-mill or otherwise. It is then put into a litre of pure water and allowed to stand in the cold eighteen to twenty-four hours. The water, which has by this time dissolved out most of the soluble albumen, salts, etc., from the meat, is now filtered through a cloth. One per cent. (ten grammes) of peptone and a half per cent. (five grammes) of common salt are then added. Gelatine in the proportion of five to ten per cent., or even more, or agar in the proportion of 0.5 to one per cent., are also added for reasons which will become apparent presently. But this mixture is acid, so for the cultivation of bacteria and yeast fungi it is necessary to neutralize with carbonate of soda. Gelatine itself has an acid reaction, so the neutralization must take place after its addition and solution by heat; but agar is neutral, so that where it is used it is immaterial at what point the soda solution is added. In both cases the mixture is now boiled until all the coagulable albumen is precipitated, and poured at once upon a hot paper-filter which has been just before washed with boiling water. If the filtrate is not absolutely clear, a small amount of egg-albumen is added, and it is again boiled and filtered. While it is still hot 5–10 c.c. of the filtrate are poured into test-tubes stopped with cotton wool. Now, it is evident that the cotton will prevent the subsequent entrance of organisms from the air, but the cotton wool itself and the test-tubes all have organisms clinging to them, so that before the nutrient gelatine or agar is poured in they must be sterilized, *i.e.*, freed from adherent germs. This sterilization is effected by plugging the tubes pretty tightly with cotton and heating them up in an air bath to 140°–150° C. (284° to 302° F.) for about an hour. But in the process of filtering and in filling the tubes organisms are likely to find their way in, so that after the tubes have been filled they must be again sterilized.

Koch's steam sterilizer.

This is accomplished by subjecting them to a temperature of 100° C. in a Koch's steam sterilizer. The sterilizer is simply a metallic cylinder set upright upon a boiler, so that all the steam which escapes from the boiler streams through the cylinder. It has been found that all objects placed in the cylinder are brought up to 100° C. (212° F.) in a few minutes after the steam begins to be given off. The sterilization in the steam apparatus has to be repeated upon three successive days for the following reason: The first sterilization kills all the vegetative cells, but we have seen that spores resist the boiling temperature for several minutes. The spores which were not killed in the first sterilization will have germinated by the second or third. It would simplify the process to steam the tubes for a half or three-quarters of an hour at once, for this would kill vegetative cells and spores as well, and agar may be treated in this way. But if gelatine is boiled too long at a time it turns to paragelatine, so that the sterilization has to be effected as above described.

Potatoes for bacterial cultures.

The method of preparing potatoes is very simple. Pieces of potatoes, with the skin removed, are put into some convenient vessel and steamed in the sterilizer for an hour or more. For reasons readily understood, the vessels containing the bits of potatoes must have an arrangement for excluding the micro-organisms of the air. Small glass dishes with perpendicular sides, and tops to fit over them, are useful for this purpose (Esmarch). The dishes should be of such a size that a thick round slice of potato will about fill one of them, and the flange of the top should come well down around the sides of the dish. Wide test-tubes plugged with cotton serve also equally as well. In this case the potatoes are cut in the shape of cylinders and fitted nicely into the tubes. The cylinders should have one side cut away obliquely, so as to afford a greater surface. Of course, the dishes and test-tubes may be first sterilized in the hot-air bath, but it is hardly necessary.

Blood-serum.

Blood-serum is prepared by allowing a quantity of blood to stand until the serum separates from the clot. It is then drawn off with a pipette and distributed into sterilized test-tubes as for agar and gelatine. It is desirable to catch the blood, in the first place, with all possible aseptic precautions, in a sterilized vessel. The carotid artery of a dog or other animal affords a convenient source. The instruments used in opening the artery, and the cannula which is inserted, should be first heated, *i.e.*, sterilized, in the Bunsen flame and then allowed to cool. The blood is allowed to flow into a wide-mouthed vessel, which has been sterilized by heat and has a cotton stopper; after the serum separates it is drawn off as already indicated. If the process has been successfully accomplished it is unnecessary to sterilize the serum. It can be at once coagulated by placing the test-tubes containing it in a slanting position in a special apparatus, and subjecting them to a temperature of not above 70° C. (158° F.) for three hours. If desired, the serum may be first sterilized by Tyndall's method, which consists in keeping the tubes at a temperature of 60° to 65° C. (140° to 149° F.) an hour or more at a time, for five or six successive days. The principle of this is readily understood from what has gone before.

Other media.

Other media, such as chicken-broth, veal-broth, and so forth, have been employed, but the three media above described are more employed than any other. They are sometimes varied, for special purposes, by the addition of sugar, glycerine, etc.

Applicability of the various media.

The most useful of them all is nutrient gelatine, but its use is limited to comparatively low temperatures, for it becomes liquid at about 22° or 23° C. (71.6° to 73.4° F.). The other media may be used at all temperatures. Gelatine is liquefied by many organisms, and Sternberg has shown that this liquefaction is not necessarily dependent upon the growth of organisms, for cultures of liquefying organisms, in which the latter had all been killed by heat, were capable of liquefying a second tube of solid gelatine, even when introduced in small amounts. Only one or two organisms as yet known liquefy agar. Where it is not specially mentioned in the following, it is understood that it is not liquefied. Most organisms have a very characteristic growth upon gelatine and potatoes; their growth is less characteristic upon agar.

The French school use bouillon without the addition of gelatine or agar, but the growth of organisms is not as characteristic in liquid media; and for purposes of isolating various species of organisms, and for the study of pure cultures, the solid media possess very great advantages.

Methods of Obtaining Pure Cultures.—Various methods of obtaining pure cultures have been suggested, and more or less successfully employed. Lister suggested a method which is essentially the same as that employed by Miquel and the French school generally. It consists in diluting a suspension of the micro-organisms to be isolated with sterilized water or other liquid, so that in a certain volume, *e.g.*, one drop, it is estimated that only one organism is present. Several flasks of bouillon are inoculated with one drop each of the diluted suspension, so that only one organism is thus introduced and grows out to form a pure culture. But this and the other methods now employed by some of the French school are so far inferior to those which we owe to Robert Koch, that I shall restrict myself to a description of the latter.

Solid media.

Solid media had been already employed by Klebs and others, but Koch's adaptation was so original that it may almost be said that he was the first to use them. Koch's methods are very readily understood, and their advantages are manifest.

It is plain that a number of different species may grow

for a longer or shorter time, side by side, on the surface of a potato or upon a layer of gelatine, without coming in contact, at least until the colonies grow so large that they touch; or, in the case of nutrient gelatine, until the latter becomes liquefied. If, on the other hand, liquid media are used, all the species which happen to be present are mixed together by the currents in the liquid, by their power of independent motion, etc. If, now, a trace of any of the isolated colonies on the potato or gelatine be inoculated into any proper medium, and the culture thus made protected from subsequent contamination, it is evident that it will be a pure culture. It is also equally evident that a pure culture cannot be obtained by inoculating directly from any liquid containing more than one species, for every trace of the liquid will almost certainly contain representatives of each of the species present.

Advantages of the same.

To illustrate the actual process, suppose it is desired to separate the various organisms in any substance which contains them. A tube of nutrient gelatine, as above described, is liquefied at a temperature not exceeding 40° C. (104° F.), and a small quantity of the substance under examination is introduced and thoroughly disseminated through the gelatine. The contents of the tube are then poured out upon a cold glass plate which has been previously sterilized in the hot-air bath. The plate is allowed to stand under a cover till the gelatine is solidified, and it is then transferred to a glass dish with a cover, and placed at a temperature of 18° to 22° C. (64.4 to 71.6° F.). In a few days there will be a number of dots apparent in and upon the gelatine, and a microscopic examination shows that these dots are little masses of micro-organisms. Each one of these masses, or *colonies*, is composed of micro-organisms of the same sort; for while the gelatine was fluid the various organisms were distributed through it, and when the gelatine became solid each separate organism, or zoöglœa, was fixed in the place where it happened to be, and had to remain there and grow without interfering with any neighboring organisms. If a trace of one of these colonies is introduced into a tube of solid gelatine, it grows and constitutes a pure culture.

Process for isolating bacteria.

If agar is used the process is essentially the same. Agar does not become liquid at any temperature below the boiling-point of water, and becomes solid again at 40° C. (104° F.). So it becomes necessary to liquefy it and allow it to cool down nearly to the solidifying-point before introducing the substance under examination. In practice there are always a number of dilutions made from this first or "original tube," by inoculating a second from it, and a third from the second, and so on. The reason for this is, that usually there are so many organisms in the first tube that when they grow out they may come in contact with each other, and thus one colony may contaminate another. But if several diluted plates are made, one or more of them will have the colonies well isolated, and they may be studied and used for inoculations.

When the plates are examined there is always danger of contamination from the air, or contact with the fingers, etc., so that Esmarch's modification of the Koch-plate method has great advantages. According to Esmarch's method, the original tube and dilutions are made just as in the other, but instead of pouring the gelatine or agar upon sterilized plates, a rubber cap is fitted over the tubes and they are held horizontally and twirled in ice-water till there is a film of the nutrient medium covering the inside of the tube. Dr. Booker, in the Johns Hopkins Pathological Laboratory, instead of using ice-water, rolls the tubes in a groove melted in a block of ice. This avoids the use of rubber caps, which sometimes permit the ice-water to run into the tubes. After the colonies have grown out, they may be examined, under the lower powers of the microscope, through the walls of the tube. They are thus not exposed, for the cotton remains in; but even when it is removed for purposes of transplanting, etc., the danger of contamination is reduced to a minimum. The Esmarch tube is, therefore, a most valuable contribution to our technique.

The inoculation of the gelatine and the transplanting from colonies are effected by means of a platinum wire melted into the end of a long glass rod. Each time before it is used the wire is glowed in the Bunsen flame, and the glass handle is also passed a few times through the flame. Cultures may be made either with a straight platinum wire, by taking a trace of a colony, or culture, upon the end of it and simply thrusting it into a tube of gelatine or agar; or the surface of any of the media may be inoculated by means of a platinum loop. The latter cultures might be called smear-cultures, and the former stick- or stab-cultures. Agar and gelatine for smear-cultures are allowed to solidify with the tubes in an oblique position, so as to afford a greater surface.

Pure cultures.

Several methods have been recommended for the cultivation of anaërobic organisms. The air may be excluded from the colonies upon plates by covering the gelatine or agar with a thin sheet of isinglass, applied directly to the surface. Another method is to place the plates under a bell-glass and displace the air with hydrogen or CO_2. Test-tubes of peculiar construction have also been used.[1] These test-tubes have a narrow glass tube opening in the side, about 5 ctm. from the bottom, just above the gelatine or agar. The tubing projects for about 3 ctm. at right angles to the test-tube, and it then bends downward and is plugged with cotton. The air in the test-tube is displaced by connecting the narrow tubing with a CO_2, or, preferably, with a H generator, and allowing the gas to stream through. As soon as the air has been displaced the upper end of the test-tube and the narrow tubing are melted off. A modification of these tubes consists in having the narrow tubing to project down into the bottom of the test-tube, so that the gas bubbles through the gelatine, or agar, which in both cases is kept liquid till after the gas has been allowed to stream through. Still another way is to make Esmarch tubes and fill them afterward with gelatine or agar, as the case may be. Flasks with narrow necks and a tube projecting from the side have also been used as follows (Hüfner, Rosenbach): The agar is boiled in one of these flasks till all the air is replaced by the gases from it, and the narrow neck and projecting tube are sealed. This projecting tube has had some of the material containing the anaërobic organism previously introduced, and after the agar has cooled down to 40° C. this material, which must be fluid, is driven into the flask by gently heating the end of the tube. Anaërobic organisms only grow at the bottom of the tube in a stab-culture, but if the air is excluded by a layer of oil they grow nearer the upper part. They grow at the bottom of the vessel in liquid media.

Cultivation of anaërobic micro-organisms.

The methods are all simple and readily understood, but require great care in manipulation.

METHODS OF EXAMINATION.—The difficulty of distinguishing between bacteria and cell-nuclei, and so forth, which Henle met with, was overcome in the most satisfactory way by Weigert's brilliant discovery of the tenacity with which bacteria retain watery solutions of the aniline dyes. Nearly all parts of a tissue are readily decolorized, after staining with various aniline colors, by treatment with acids, etc.; but to effect a decolorization of the bacteria, the decolorizing agent has to be allowed to act for a much longer time. This is a perfectly decisive, sharp reaction, and renders the detection of bacteria in most cases very simple.

The limits of the present paper will not allow a full account of the various methods of staining, and I can merely give a few general principles and one or two special applications.

Methods of staining bacteria.

Ehrlich distinguishes two classes of aniline dyes, acid and basic. The acid dyes need not necessarily have an acid reaction, but they include all the dyes which form salts with the bases, and whose coloring property is consequently due to an acid radical. The basic colors are generally not found as free bases in the market, but are sold as salts; thus fuchsine is a chloride or acetate of rosaniline. The basic dyes are almost exclusively used as stains for the bacteria. The cell-nuclei also show an affinity for this class of dyes, and in order to get rid of the

diffuse stain in other parts of the tissues the latter are decolorized in very dilute acetic acid or in alcohol. This treatment leaves the bacteria and nuclei stained, and the rest of the tissues unstained. If sections treated in this way are afterward slightly stained with some contrasting color, the bacteria and nuclei often show to better advantage. The most usual colors are methylene blue, gentian violet, fuchsine, and methyl violet, all in watery solutions. These solutions are conveniently prepared by having saturated alcoholic solutions and adding a few drops to water as required. Saturated alcoholic solutions may be kept indefinitely.

FIG. 3395.—From a Section of the Kidney of a Mouse, showing the Capillary Spaces filled with Anthrax Bacilli.

Bacteria in sections of tissues are stained by allowing the latter to remain from twenty minutes to several hours in a watery solution of any of the above dyes. They are then put for a very few seconds into very dilute acetic acid, about 1 drop acid to 20 c.c. water, and are afterward thoroughly washed in water, dehydrated in alcohol, cleared up, preferably, in origanum oil, and mounted in balsam dissolved in xylol.

Most bacteria stain very well in this way, but tubercle bacilli require special staining as follows: 11 c.c. of a saturated alcoholic solution of fuchsine or gentian violet, 100 c.c. of a saturated aqueous solution of aniline oil, and 10 c.c. of alcohol, are mixed. The aqueous solution of aniline oil is prepared by thoroughly shaking 6 or 7 c.c. of the oil in 100 c.c. of water, and after fifteen minutes filtering. Sections must be left in the staining fluid twenty-four to forty-eight hours, and are then decolorized in twenty to thirty per cent. nitric acid, or, better, in dilute hydrochloric acid and alcohol mixed as follows: 100 c.c. of alcohol, 20 c.c. water, and 1 c.c. concentrated hydrochloric acid.

Staining of tubercle bacilli.

Tissues are embedded and cut in the usual way. Celloidine and paraffine are used for embedding. A mixture of glycerine and gelatine, in such proportions as to be of a firm consistence at ordinary temperatures, is a convenient embedding medium for bacteriological purposes. A piece of tissue to be embedded in this way, after it is thoroughly hardened in alcohol, is placed on a bit of cork and the gelatine-glycerine is heated till it melts, and is then poured over it. As soon as the gelatine-glycerine becomes hard, which takes place in a few minutes, the cork, with the tissue thus attached, should remain about a day in alcohol, when the tissue will be ready for cutting. The sections must be cut as thin as possible, and can be stained as above described.

Embedding.

The so-called cover-glass preparation (Fig. 3396) is of especial value in the examination of bacteria. They are prepared by spreading a very small quantity of the material to be examined on a thin cover-glass. If the material is too dry it is well to have a very small drop of sterilized water or salt solution on the cover-glass. After the cover-glass is thoroughly air-dried, it is passed once or twice rapidly through the Bunsen flame and then colored in the same way that sections are. They need not be treated afterward with alcohol and oil, but can be mounted in balsam as soon as they are dry. Tubercle cover-glass preparations are stained in the way already described for the tissues. Tuberculous sputum and preparations from cultures may be rapidly stained by heating the coloring fluid till it gives off visible vapor. There are, besides these, many methods for staining tubercle bacilli, but I must refer the reader to some one of the special works on the staining methods for a description of them.[2]

Cover-glass preparations.

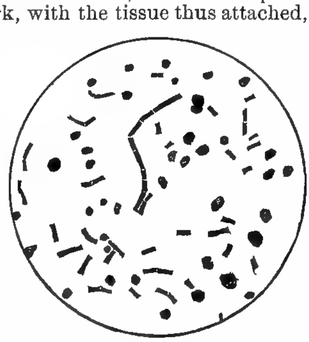

FIG. 3396.—Cover-glass Preparation from the Blood of a Mouse, showing Anthrax Bacilli. × 400.

Many bacteria are very beautifully stained in tissues and on the cover-glass by Gram's method, which consists in staining with the gentian violet solution, which has already been described, for tubercle bacilli, and decolorizing in dilute Lugol's solution and absolute alcohol. The dilute Lugol's solution consists of 2 grammes of iodide of potassium, 300 c.c. water, and 1 gramme of iodine.

Gram's method.

It is often desirable to examine micro-organisms while they are alive to determine whether they have independent motion, their method of forming spores, etc., and this is done in so-called drop-cultures. A very small drop of beef-broth, prepared as above, without the addition of gelatine or agar, is put on a very thin cover-glass and inoculated with a trace of a pure culture of the micro-organism to be examined. The slides used for this purpose have an excavation in the middle so constructed that a cover-glass will fit over it and close it. The cover-glass with the inoculated drop of sterilized beef-broth is put on one of these slides, so that the drop hangs down into the excavation. A small amount of vaseline is smeared around the edges of the excavation in the slide, so that when the cover-glass is put on it adheres all around and prevents the broth from evaporating. The cover-glass and slide are first sterilized by passing them several times through the flame. After the drop-culture is prepared it is put at a temperature of 35° to 37° C. (95° to 98.6° F.), and examined with the oil immersion-lens from time to time. It is always well to prepare a number of drop-cultures at a time, for it often happens that they become contaminated in their preparation. Such cultures may be afterward allowed to dry, and stained and mounted for preservation.

Drop-cultures.

INOCULATION OF ANIMALS, AND DESCRIPTION OF THE PATHOGENIC PROPERTIES OF ORGANISMS.—Guinea-pigs, rabbits, and mice afford the best material for testing the pathogenic properties of micro-organisms. They are more susceptible to infectious diseases, as a rule, than other animals, and are easier to handle. But dogs, cats, sheep, etc., are sometimes used. In some cases even human beings have been used.

The material for inoculation is either simply inserted under the skin, or suspended in sterilized water, three-fourths per cent. salt solution, bouillon, or other convenient liquid, and injected into a vein. The outer vein of the ear of a rabbit is generally selected for this purpose, and the injection is made with a previously sterilized Pravaz' or Koch's hypodermic syringe. In subcutaneous inoculations a pouch is made under the skin with a sterilized instrument and the material introduced, or a suspension is injected with a hypodermic syringe. The root of the tail is generally selected in inoculating mice, and the abdomen of other animals. These points are merely selected for convenience, the object being to introduce the organisms so that they may be taken up by the circulation.

If animals are so inoculated with a substance containing organisms of a disease to which they are susceptible, they sooner or later show all the symptoms peculiar to the disease. Cover-glass preparations from the blood, spleen, liver, etc., show the characteristic organisms in greater or less abundance, and the organisms can be cultivated in most cases. Pure cultures can generally be made, with proper precautions, directly from the blood, etc., but it is preferable to make plates or Esmarch tubes first.

If an organism is cultivated through a number of generations outside of the living body, and is always followed by typical symptoms when inoculated in minute quantities, the evidence of its pathogenic power is complete. If it is not cultivated through several generations before it

is inoculated, the objection can be raised that some poisonous substance from the original material may have been transferred; but, of course, this objection falls to the ground if the culture which has been used is the last of a long series of transplantations, for traces of the original material could not possibly be transferred so often. Such a culture represents simply the organisms which have descended from the original culture. In this case the proof is perfectly conclusive; but suppose the organism is only pathogenic for man? In this case a most important point in the proof fails, and before bacteriology was as firmly established as it now is, it seemed that it was a necessary point in the proof. But authorities are now agreed that, although the actual production of the disease in the lower animals may be wanting, still, in such cases, bacteria have been shown, beyond reasonable doubt, to be the cause of the disease. Before our methods of diagnosing bacteria were as perfect as they are now, we were unable to say positively that a certain bacterium was found in every case of a given disease; we could only say that morphologically similar bacteria were constantly present. At present, however, it is only necessary to find an organism constantly present, with characteristics sufficiently marked to recognize it in all cases. It must be absent in all other diseases and in healthy individuals. Among other examples, Bumm's failure to produce gonorrhœa in the lower animals with his cultures was no proof that the organism was not the cause of the disease in man, because the lower animals have an immunity from gonorrhœa. Bumm found his organism in all cases, and it was so well marked that it could be readily recognized. It was absent in all other cases, and the production of typical gonorrhœa in man (see below) was hardly necessary, though, of course, it strengthened the proof.

Under what circumstances is an organism said to be pathogenic?

Grounds for Accepting Specific Differences in Bacteria.—In the foregoing discussion I have assumed that there are distinct species, reserving this hotly contested point for special consideration. Hallier has been already quoted incidentally as having claimed that all infectious diseases are caused by an organism which he had discovered. His idea was that all organisms of disease are simply various forms which a certain fungus assumed under various circumstances. He thought that he had in his coccus found the cause of the infectious diseases, and that this coccus was derived from a mould fungus. It is easy to understand how Hallier was led into his error, for, as everyone acquainted with the subject knows, micrococci can be found in all sorts of diseases, and if the cocci are not cultivated with great precaution mould fungi invariably take possession of the culture. His theory was very plausible, and it fitted in exactly, even in the minutest details, with all the observed facts; but it disregarded all of Henle's postulates, and was consequently wanting in proof. Cocci were constantly found by Hallier; this would satisfy Henle's first demand if the cocci found at one time were of the same species as those found at another in the same disease; but supposing they were the same, they would have to be isolated, and with the methods known in Hallier's day this was impossible. Even starting from a pure culture, there was no guarantee that it remained pure; on the contrary, there was almost an absolute certainty that it would become contaminated, and that the contaminations would finally crowd out the original species, *i.e.*, that mould fungi would at length occupy the field, for these fungi are specially apt to contaminate our cultures. It is by no means so easy to reconcile many recent observations with the classification of organisms into distinct species. Pasteur has observed that certain micro-organisms lose their pathogenic properties under special conditions. Thus chicken cholera, rabies, etc., lose their virulence when inoculated into certain animals, and this loss of virulence is transmitted. Anthrax virus loses its power also under certain circumstances. Thus Pasteur was able to get cultures of anthrax and other organisms of various strengths, one strength capable of killing mice, but not fatal to larger animals, a still weaker sort incapable of killing even mice. But if the virus which is capable of killing mice, and is incapable of killing larger animals, be once passed through a mouse it resumes its virulence for larger animals. This is mentioned to show that organisms are subject to most important changes of properties, and under the head of morphology we have seen that they may suffer quite marked changes of form, so that every characteristic seems more or less variable, at least in a number of cases. In spite of all this, however, the weight of evidence is in favor of a classification into distinct species, for the changes just spoken of are brought about by definite, controllable causes, and had best be regarded as mere expressions, in each case, of wide but nevertheless limited power of variation. We may transplant various cultures with absolute certainty that we shall obtain similar cultures, generation after generation, if we use the proper precautions as to the avoidance of contamination. The transplanted cultures will have the same characteristics as the cultures from which they are transplanted. The modification of the physiological function already alluded to is more decided than that observed in the higher plants. The latter are subject to decided modifications of form and function under varying conditions of nutrition, etc., but such modifications are not subject to inheritance, except when they are purposely cultivated through many generations, or result from the law of natural selection; and even then there appears a tendency on the part of the plant or animal to return to the normal type. The micro-organisms, on the other hand, as we have seen, may be stamped in one culture representing many generations, it is true, with a modification from the normal which they retain tenaciously, and such modified cultures can be cultivated under circumstances which we would suppose to be favorable to a return to the normal type, and still remain modified, generation after generation. This is a peculiarity which shows that analogical reasoning from the higher plants is misleading, and that the utmost care should be used in the observation of each experiment. Especially in the study of bacteria is the greatest possible objectivity of prime importance; every preconceived idea is a hindrance, and only results which have been obtained repeatedly under every variation of circumstances can be of any value. For this reason all observations which have as yet been made in favor of pleomorphism of bacteria are not convincing. Until it is proven by actual observation of experiments, in which every source of error is excluded, that there is a metamorphosis of species, we are forced to accept specific differences. Direct argument for the existence of species may be deduced from what has gone before.

Some of the forms known to us at the present day have existed for a very long time, for some of them have been detected in fossils. The tartar from the teeth of Egyptian mummies has been found to contain forms identical with those found as constant inhabitants of the mouth at the present day (Zopf and Miller).

The Pathogenic Bacteria.—Although there are many saprophytic bacteria which are of great scientific interest, the limits of this article will not permit a description of individual species of saprophytes. It is, therefore, thought best to restrict the description of species to the pathogenic bacteria, in view of their immediate bearing upon medicine.

The Pathogenic Cocci.—*Cocci of Pus.*—All ordinary suppuration, as met with in every-day practice, is caused by micrococci. It is true that certain chemical agents cause it also, but such cases are rare, and when they occur micrococci are usually secondarily involved.

Staphylococcus pyogenes aureus (Ogston, Rosenbach, Krause, and Passet), *S. p. albus* (Rosenbach, Passet), and *S. p. citreus* (Passet), are the most common pus-producers. One or more of them are found in acute abscesses, in empyema, and in ordinary boils. They are often present in pyæmia, ulcerative endocarditis, and osteomyelitis. They therefore cause many diseases which differ clinically. S. p. aureus is perhaps the most common, and albus next.

These organisms are round, and about 0.87 μ in diameter. They usually form into clumps, but isolated cocci

and short chains are also met with. They are readily stained with the ordinary watery solutions of the aniline dyes.

They grow upon all the different media at low and high temperatures. Colonies in gelatine are visible in a few days in the form of little white dots sunken down into the substance of the gelatine, owing to a little zone of liquefaction around each colony. These little funnel-shaped depressions are very apparent when the plate is seen at a very acute angle. The liquefaction gradually spreads, and the colonies at the bottom of the liquefied zones become orange-colored if the organism is the aureus, lemon-yellow if it is citreus, and remain white if it is albus. They show a similar difference of color when cultivated upon the other media. Their growth coagulates milk in from one to eight days, with the production of lactic (and other ?) acids.

Under the lower powers of the microscope the colonies are light brown, with a dark centre. They are perfectly circular, and have a sharp, smooth edge. Subcutaneous inoculations of traces of the cultures have no effect upon mice, guinea-pigs, or rabbits. Inoculation upon the cornea of the last-named animal causes an inflammation and a grayish-white infiltration which passes away in a few days. Larger amounts rubbed up in bouillon, etc., and injected subcutaneously, cause local abscesses, which either remain local and heal, or lead to general infection and pyæmia. Injections into the peritoneum or into a vein generally prove fatal in from two to nine days. The most characteristic lesions are found in the kidneys, which are filled with yellowish-white foci varying from microscopic points to the size of a pea. The foci occasionally form wedge-shaped masses.

Staphylococcus pyogenes salivarius was obtained from saliva by Biondi, in Koch's laboratory. It differs from the albus and aureus in cultures by liquefying gelatine much more slowly and having a whitish color, which afterward turns gold-yellow. It often forms a skin over the surface of liquefied gelatine.[3]

Staphylococcus of the Clou de Biskra. The Clou de Biskra is an endemic disease of Aleppo, Bagdad, Biskra, and Tunis. It is characterized by nodules which appear upon the face and extremities, and which break after a year or more. The cocci have been found in the blood of individuals affected with the disease, and have been cultivated in calf-broth. They lose their pathogenic properties after they are cultivated for a time.

Streptococci of Suppuration.—There are also streptococci which produce suppuration. They all resemble each other under the microscope and in culture, and differ essentially only in virulence. They are round and somewhat larger than the staphylococci. Some of the individuals are larger than others, and some of these are probably arthrospores. Colonies on gelatine are sharply marked and raised slightly above the surrounding surface, without spreading over it. They always remain small, and do not cause liquefaction. Under the microscope they are circular, seldom oval, of a yellow color with a granulated surface. Older colonies are almost brown and the edges are irregular. On agar they are of a flat conical shape, sloping off all around in steps from the centre to the periphery. Stick-cultures in gelatine show a number of isolated points of growth upon a part or all of the line of puncture. Growth upon potatoes is not visible to the naked eye for a long time. They grow slowly upon all media, but more rapidly at 35° to 37° C. (95° to 98.6° F.). The varieties are:

Streptococcus pyogenes. This organism is found in a great many cases of suppuration, but does not seem to act as energetically as the staphylococci. It causes chiefly inflammations which follow the lymphatic vessels. It permeates the tissues, but seems to require some little time to cause the death of the latter. It has also been found in progressive gangrene and pyæmia. It is probably identical with Fehleisen's streptococcus of erysipelas. It hangs together in chains of four to ten or more individuals.

Subcutaneous inoculations of small quantities either have no effect upon mice, or produce local abscesses which occasionally lead to death. It produces a transient swelling and reddening of the ear in rabbits. But with this exception, subcutaneous inoculations, and even intravenous injections, are usually without effect unless the animals have been first poisoned, or there is a lesion of the aortic valve. In the latter case there follows an extensive endocarditis in from two to five days.

Streptococcus septo-pyæmicus is probably identical with S. pyogenes. It was obtained by Biondi from two cases of primary erysipelas of the larynx, and once in angina phlegmonosa (loc. cit.).

Coccus salivarius septicus was also found by Biondi in the saliva of a patient suffering from puerperal septicæmia. It was also fully described in the above article, together with the bacillus salivarius septicus, which is probably identical with the M. Pasteuri (see below).

Streptococcus pyogenes malignus (Flügge). This coccus was obtained, in the Göttingen Hygienic Laboratory, from a spleen in a case of leucæmia. As the name implies, it is very virulent. It kills mice and rabbits almost always when inoculated in small quantities under the skin. It produces a somewhat extensive local abscess at the point of inoculation, and diseased foci, filled with the streptococci, are found in the spleen and other organs, as well as in the blood. The animals often have one or more joints filled with the streptococci.

Streptococcus articulorum (Löffler) has been found in a large number of cases of diphtheria, but probably has no causal connection with that disease. It forms very long chains of one hundred or more links. The colonies differ somewhat from the above description in that they are grayish under the microscope and have a wavy margin. Intravenous injections produce marked suppurative changes in the joints as a primary effect, and the animals gradually die. The joint affections with the other streptococci are secondary. Rabbits inoculated under the skin of the ear are affected just as with S. pyogenes.

Streptococcus septicus (Nicolaier, Guarneri) does not form chains under all circumstances, and grows more slowly than the other streptococci. Traces of a culture suffice to kill mice and rabbits with absolute certainty in two or three days. The cocci are found in all the organs and tissues in great abundance.

Micrococcus pyogenes tenuis (Rosenbach) was found in a few cases of closed abscesses. It does not tend to form into masses or chains. It often shows an unstained central portion and deeply stained poles. It forms almost transparent masses upon agar, afterward becoming more opaque. Experiments upon animals have not yet been made.

Micrococcus gonorrhœæ, gonococcus (Neisser, Bumm). This organism causes gonorrhœal inflammation of the urethra, bladder, ureters, pelvis of the kidney, cervix uteri, and conjunctiva. It has also been found in gonorrhœal inflammation of the knee-joint. Its growth is restricted to these localities, as far as observation goes.

It is a diplococcus rarely undivided, and is sometimes seen in groups of four. The apposing surfaces are either straight or slightly concave, so that the intervening space between the two halves of the diplococcus is double convex. The space is usually unstained. The long diameter of the diplococcus is about 1.25 μ, the transverse diameter about 0.6 μ. Watery solutions of methylene blue stain the cocci readily. They do not stain by Gram's method. It only grows upon blood-serum, and poorly at best. It requires a temperature of 32° C. (89.6° F.), and the cultures often die without any apparent cause. Inoculations upon various animals have been followed by negative results, but inoculations upon man have been successful. Its pathogenic power is in inverse proportion to the age of the disease. Secretions from old chronic cases have often to be examined repeatedly before finding the organisms, but cover-glass preparations from fresh cases always show them. It is the only cause of gonorrhœa, and is, therefore, of great diagnostic value. Errors have been made in mistaking the following for it:

Micrococcus subflavus (Bumm) has been found in catarrhal affections of the bladder, in pemphigus neonatorum,

in a mammary abscess, and in colpitis. It resembles the gonococcus in cover-glass preparations, but is readily distinguishable by the fact that it grows readily upon gelatine and serum at ordinary temperatures, and liquefies them both. Colonies are at first white, but afterward run together and form a yellowish mass, which finally becomes of an ochre color. It is not pathogenic for animals, but produces abscesses in human beings.

Micrococcus found in erysipeloid inflammation (Rosenbach) of the hands and fingers of tanners, butchers, and others who handle animals. It grows upon gelatine and agar, making extremely small colonies.

Micrococcus tetragenus (Gaffky) is found in tuberculous and other sputum, and upon the walls of tuberculous cavities of the lungs. It is 1 μ or more in diameter, and there are generally four together, but in many of them the tetrads are not distinctly marked. Each tetrad is surrounded by a gelatinous envelope in preparations from sputum and lungs. Gelatine colonies are white, the superficial ones projecting above the surface. Under the microscope they are yellow, and either round or lemon-shaped, with a nodulated surface like a mulberry; the circumference is consequently regularly scalloped.

Micrococcus Pasteuri (Sternberg) is frequently found in the saliva of healthy persons. It was first observed by Sternberg, who found that it produced septicæmia in rabbits, and could be cultivated at higher temperatures; it very rapidly lost its virulence in cultures. A. Fraenkel regards this organism as the cause of croupous pneumonia.

Micrococci have, furthermore, been found in variola, vaccine-matter, scarlatina, diphtheria, cerebro-spinal meningitis, influenza, ozæna, hæmophilia neonatorum, acute yellow atrophy of the liver, yellow fever, trachoma, porrigo decalvans, and granuloma of the skin. But none of them have been, as yet, sufficiently studied to establish their relation to the processes in which they are found. The same, probably, holds true of the micrococci found in Rinderpest in Russia and pleuro-pneumonia of cattle.

The following micrococci have also been partially studied:

Streptococcus perniciosus psittacorum (Eberth, Wolff) was found in nodules of the lungs, spleen, blood, etc., of parrots which had died of a peculiar disease.

A streptococcus was found by Charrin in the blood and internal organs of rabbits which had died of anthrax. It was called the micro-organism of septicæmia consequent upon anthrax. It produced septicæmia when inoculated, and is, probably, identical with Koch's coccus of septicæmia (see below).

Streptococcus bombycis (Béchamp) produces coma in silkworms. A different disease is caused by *nosema bombycis* (Cornalia, Lebert, Nægeli, Pasteur).

Micrococcus of progressive necrosis of the tissues in mice, destroys all sorts of tissue, even tendons. Animals inoculated with it die in about three days. The blood and internal organs remain free. Koch obtained the organism by inoculations of foul substances upon the ear of mice, but only got it pure by using field mice.

Koch, furthermore, obtained micrococci in cases of progressive abscess caused by injecting putrid blood; also a micrococcus in pyæmia in rabbits, and another in septicæmia of rabbits.

Pathogenic Bacilli.—*Bacillus anthracis** attacks whole herds of cattle and sheep, sometimes producing local boils, but generally it kills by producing septicæmia. Most animals and human beings are usually killed when they become inoculated with the minutest trace of a material containing the bacillus anthracis. Algerian sheep, white rats, adult dogs, and frogs are almost insusceptible. Natural infection takes place by the introduction of the spores into the alimentary canal along with the food, and the disease consequently begins in the intestines. Cattle and sheep are especially sensitive to this mode of infection. The bacilli are formed in every organ and tissue of the body in the diseased animals (Figs. 3395 and 3396). Inoculations of very small quantities always kill mice in about twenty hours, and guinea-pigs and rabbits in twice that length of time.

The rods vary in length from 5 to 20 μ, and in breadth from 1 to 1.25 μ. They often hang together in long threads. The ends are slightly thickened and very sharply cut across, or even somewhat concave. They have no flagella and no independent motion. The forms of involution are often met with, especially in old cultures. Spores are formed in the long threads; they are oval, and each one is embedded in a round gelatinous capsule. The latter becomes oval, and is broken through when the spore germinates. They are very resistant, and are not killed by boiling in water one or two minutes. Direct sunlight kills them in a few hours (see p. 330). Anthrax spores are never found in the blood or other organs.

The bacillus anthracis grows very readily in alkaline urine, alkaline vegetable infusions, and the customary nutrient media at low and high temperatures, in the latter case usually forming spores in a few days. It thrives best in free oxygen.

Gelatine colonies under the microscope are greenish-black, and the surface is marked with parallel, zigzag, or shaggy lines; this is most noticeable around the edges. There are often long threads, twisted like a rope, running off from the colony. It gradually liquefies the gelatine, which becomes syrupy.

Bacillus œdematis maligni (Koch). Before the days of antiseptic surgery this organism often caused progressive gangrenous œdema and emphysema. It is usually present in decaying matter, in dust from dwellings, old rags, hay, etc., and in earth which has been fertilized with foul fæcal matter; in the latter it is often associated with the bacillus of tetanus. It probably plays an important part in putrefaction. It can be obtained by inoculating various animals subcutaneously with rich garden earth, and may then be inoculated from one animal to another. Such inoculations of garden earth sometimes produce tetanus. Malignant œdema is characterized by extensive infiltration around the point of inoculation of an abundant, clear, reddish fluid containing the bacilli in great abundance. There are also gas-bubbles here and there in the fluid. The internal organs are not much altered, but the serous surfaces contain numbers of bacilli. The bacilli are not present in the heart's blood before and immediately after death, but appear very soon post mortem. Mice are an exception to this rule, and as the bacilli are found in their blood, etc., in great abundance just after death, malignant œdema has often been mistaken for anthrax in these animals. Mice die in sixteen to twenty hours after inoculation.

The inoculation requires to be made with larger quantities than is the case with anthrax.

The bacilli of malignant œdema resemble anthrax bacilli. Individual bacilli measure from 3 to 3.5 μ by 1 to 1.1 μ, and have a tendency to form long chains of ten or more. These chains are generally bent and twisted. They often have a granular appearance in stained preparations, and the ends are more or less rounded. They form long threads in the blood, etc., in contrast with the anthrax bacilli. Independent motion is sometimes, but by no means constantly, observed. Spores are found in the isolated bacilli, but not in the long threads. It is an exquisite anaërobic organism. It liquefies gelatine, agar, and blood-serum, with the production of gas-bubbles; the gas has a faint, stale odor.

Bacillus of sympathetic anthrax, black-leg, Rauschbrand, etc. (Arloing, Cornevin, and Thomas), causes an endemic disease of cattle. Animals affected with the disease have hard, tense nodules under the skin and in the muscles, especially in the fleshy portions of the body, such as the rump, breast, etc. They may also have, secondarily, all the symptoms of an acute infectious disease, such as loss of appetite, disinclination to move about, etc.; or the constitutional symptoms may be primary and may be followed by the local. The nodules are at first very painful on pressure, but gradually they become insensitive. The

* Observed first by Rayer in 1850, and in 1855 by Pollender, independently of Rayer; Davaine, in 1863, claimed that the bacillus caused the disease, and this was established by Koch in 1876.

swollen parts present upon pressure an emphysematous crackling; hence the German name Rauschbrand. The nodules are rarely found in the deep muscles. The fever reaches about 43° C. (109.4° F.), but before death the temperature sinks to subnormal. Animals die in thirty-six to forty hours after the fever begins. The stage of incubation is from fourteen to twenty hours. Animals often recover when there are no local symptoms, and are then protected from subsequent infection; but they almost always die if the nodules make their appearance. The sound given out on pressure of the nodules is due to an accumulation of a gas in the cellular tissue; the gas is composed of 13.15 per cent. CO_2, 76.51 per cent. H, and 10.34 per cent. N. The internal organs are covered with a dirty-red fluid, as if red wine had been poured over them. Inoculations of the juice of an affected muscle, or with the gall, are successful with various animals if used in considerable quantities—two or three drops. Guinea-pigs are more susceptible and die from inoculations of much smaller quantities. The organism presents also very remarkable peculiarities. Calves up to five months old show no symptoms when inoculated with as much as six drops. They die from inoculations of larger quantities, and are not protected by inoculations of smaller amounts. Cattle reared in a black-leg district are rarely affected after they are two years old; they have all probably suffered from the disease in a mild form and are consequently protected. Imported cattle are susceptible at all ages over five months. Inoculations with blood of diseased animals are generally not successful till just before or after the death of the latter; the blood contains very few bacilli up to that time. Inoculations with portions of a fœtus, or with the amniotic fluid of a pregnant animal suffering from the disease, have been successful. Bacilli have been found once in the urine. Natural infection rarely takes place from the intestines. Very superficial inoculations, and inoculations far removed from the fleshy portions of the body, are usually followed by insignificant symptoms, but animals so inoculated are thereby rendered insusceptible to subsequent infection. If cattle are inoculated at the extreme end of the tail, they recover, as already said; but if they have a wound in any muscular part, the bacilli lodge there and finally cause death. It is also remarkable that even intravenous and intratracheal injections cause only slight local trouble, unless the tissues are much wounded in injecting, or unless there is a lesion at some other point. All of these methods have been successfully employed for preventive inoculations, but, as will be readily understood, they are attended with risk. The methods for preventive inoculation will be discussed in another place.

Frogs inoculated with sympathetic anthrax bacilli or spores, and kept in water at 22° C. (71.6° F.), suffer apparently no inconvenience; they crepitate in fifteen to twenty hours, just as warm-blooded animals do, and their tissues are equally virulent.

The bacilli are 3 to 5 μ long and 0.5 to 0.6 μ thick, usually with a knob on one end which makes the individual bacillus resemble the tongue of a bell. The spores form in the knob-like enlargement, one to each bacillus. The bacilli are endowed with independent motion. They grow in blood-serum, gelatine, agar, etc., but have probably never been obtained in pure cultures. If a portion of diseased muscle of an animal, which has died of Rauschbrand, be introduced deep down into a tube of blood-serum or gelatine, it liquefies the media and produces gas. This organism is anaërobic.

Bacillus typhi abdominalis, typhoid-fever bacillus (Eberth, Klebs, Koch), is readily obtained in pure cultures from diseased portions of the intestines, the mesenteric glands, and the spleen, often also from the liver and kidneys. They occur in separate clumps in these organs, and are not distributed throughout them. The constant presence of this organism in typhoid fever, and its absence in all other conditions, makes its etiological significance almost certain. Injected in large quantities into the veins of various animals, and under the skin of mice, it causes death with somewhat characteristic symptoms, such as swelling of the Peyer's patches. But the death of the animals is probably due to intoxication, and not to a multiplication of the bacilli.

The bacilli are about 2 or 3 μ long, and 0.6 to 1 μ in thickness. The ends are distinctly rounded. The bacilli in cultures resemble those found in the diseased tissues, etc., but the former tend to hang together in long threads. The aniline dyes stain the bacilli rather slowly, but very satisfactorily, if allowed to act long enough. They do not stain by Gram's method, *i.e.*, they are completely decolorized by Lugol's solution and alcohol. The bacilli often remain unstained at various points, and this gives them the appearance of being notched and of having holes in them.

They grow readily, at high and low temperatures, upon all the various media—potatoes, agar, gelatine, milk, etc. Colonies on gelatine plates appear as small white dots in thirty-six hours, at a temperature of 18° to 20° C. (64.4° to 68° F.). Under lower powers of the microscope they appear light lemon-yellow, are either circular or lemon-shaped, with a sharp contour and indistinctly granular surface. The colonies which lie upon the surface of the gelatine, or which have broken through in the process of growth, are spread out flat, they never project appreciably above the surface of the gelatine. Under the microscope they have an irregular contour, often fissured at various places, and their surface is marked with zigzag parallel lines. To the naked eye they have a very delicate bluish tint. Although the growth is vigorous in all cases, it does not produce such thick masses, either in colonies or in cultures, as do many other organisms.

It grows luxuriantly upon potatoes, but the growth is invisible to the naked eye; this characteristic is not absolutely constant. On touching the surface of a potato-culture with a platinum needle, it seems to be covered with a slightly elastic skin.

At a temperature of 35° C. (95° F.), the typhoid bacillus forms oval refractive bodies much resembling spores, but they do not seem to be very resistant to agents which do not usually affect spores.

Bacillus pneumoniæ, pneumococcus (Friedländer), is found in the alveolar exudate, and in the exudate from the pleura and pericardium in cases of croupous pneumonia. It has been seen in the rusty sputum, and once in the blood. Its value in diagnosis is limited by the fact that there are quite a number of bacilli which resemble it, that it is not constantly present, and that pneumonia is caused by other organisms.

Mice are killed by injections into the thoracic cavity, and by inhalations. Post-mortem pneumonia is sometimes found which is not generally of the typical lobar variety, and the organisms are readily obtained from the diseased lungs and the blood. Rabbits are unaffected. Of 11 guinea-pigs, 6 died after inoculation, and there died one dog out of 5 inoculated.

The bacilli are short and thick, some of them look like cocci. The ends are rounded. In preparations from animal tissues the bacilli are each surrounded with a gelatinous capsule, or it may be that a single capsule envelops two or more bacilli. The bacilli have no independent motion.

They grow very readily upon various media. Gelatine colonies twenty-four hours old are white, and afterward project like little knobs above the surface. Under the microscope they have a dark granulated centre, and a narrow olive-green peripheral zone. In stab-cultures a knob forms on the upper surface of the medium, and the line of inoculation tapers as a whitish line from this knob downward, so as to make the so-called nail-growth. In old cultures the gelatine and agar become dark reddish-brown around the line of inoculation. Gas-bubbles are formed in potato-cultures.

The following five organisms bear resemblance to the bacillus pneumoniæ:

Bacillus of rhinoscleroma causes a hardening and thickening, or it may be a diffuse cellular infiltration, of the mucous and submucous tissues of the nose resembling a lymphomatous growth. The disease may spread to neighboring parts. It is comparatively rare and has

been observed chiefly in Southern and Southeastern Europe and in Central America.

The bacilli are indistinguishable in cultures and under the microscope from the pneumonia bacilli, and inoculations upon animals are followed by the same results with both kinds of bacilli.

Bacillus crassus sputigenus (Kreibohm) is indistinguishable from bacillus pneumoniæ in cultures and under the microscope. It was obtained twice from sputum, and once from the coating of the tongue. Mice die of septicæmia when inoculated with traces of a culture. Rabbits react only when large amounts are injected into a vein, and the same is true for dogs.

Bacillus pseudo-pneumonicus (Passet) is even more inclined to occur in an isodiametric form than is the bacillus pneumoniæ, and Passet called it a micrococcus; but, according to Flügge, it is a bacillus. It was derived from the pus of two abscesses. It is in many respects similar to bacillus pneumoniæ, but in stab-cultures it only forms the head of the "nail," and does not grow along the line of inoculation. Colonies are, moreover, grayish-white.

Bacillus pneumonicus agilis (Schou) was obtained from pneumonia of rabbits in which the vagus nerve had been severed. The bacilli resemble bacillus pneumoniæ, but they liquefy gelatine and blood-serum, and cultures on potatoes are reddish-yellow and spread out. Injections into the trachea and inhalations produce severe pneumonia in rabbits.

Bacillus septicus sputigenus. See Micrococcus Pasteuri.

Bacillus tuberculosis (Koch) is the cause of tuberculosis, including lupus and scrofula. No animals seem to have an absolute immunity from the disease, although they present marked differences in susceptibility. The disease is never brought about in any other way than through infection with the tubercle bacilli or their spores. Infection takes place by inhalation, by swallowing the virus, and by inoculation. The bacilli are most certain to be found at the place where the disease is just beginning to attack a new place, *i.e.*, the early stages of the disease, or the parts just commencing to be affected. At first the separate bacilli are isolated, and are found in the cells close to the nuclei; where the process is older the bacilli occur in thick clumps. In old cheesy masses, unless exposed to the air, the bacilli are not so readily found. The bacilli are almost always found in the giant cells.

The tubercle bacillus can be cultivated upon blood-serum at 35° C. to 37° C., and is said to grow best when glycerine is added. It is best obtained for cultures by inoculating a guinea-pig in the belly with sputum from a phthisical patient. After the animal dies or is killed (in from four to six weeks), a tuberculous nodule is cut out with the greatest possible aseptic precaution and rubbed up in a sterilized glass dish, and introduced into tubes of blood-serum. There is no apparent growth for fourteen days or more, it then becomes especially apparent around any little bits of tissue that have been introduced, in the form of little grayish masses which afterward turn to dry crusts. The tube should be prevented from drying out by warming the mouth of the tube and wrapping the cotton plug with thin rubber sheeting, which adheres nicely. This or some other method to prevent evaporation must be resorted to.

The bacilli are 1.5 μ to 3.5 μ long and about 0.2 μ in thickness. They are generally curved or bent at an angle; they often have from two to six spores, which have a larger diameter than the thickness of the bacilli. The method for staining has already been given on p. 333.

Bacillus lepræ (Armauer Hansen, Neisser) is found exclusively and in great numbers in all organs and tissues affected with leprosy. The bacilli are congregated into characteristic clumps, and the clumps are probably cells filled with bacilli. Some of them are similar to the giant cells containing tubercle bacilli, and are called leprosy cells. These bacilli are also met with lying free in the lymph-spaces. Bordoni-Uffreduzzi[5] claims to have cultivated the bacilli in blood-serum to which glycerine had been added. He obtained his cultures from the marrow of a leprous bone. After cultivation on glycerine blood-serum, he contends that the bacilli will grow upon our ordinary media (except potatoes and bouillon) at 22° C. to 25° C. The bacilli direct from the tissues are more readily stained than tubercle bacilli, but from Bordoni-Uffreduzzi's cultures less readily. To distinguish them from tubercle bacilli in cover-glass preparations, Baumgarten leaves them six to seven minutes in an alcoholic solution of fuchsine; decolorizes fifteen seconds in acidulated alcohol, washes in water, and colors afterward with methylene blue. Leprosy bacilli are colored red in this way, but tubercle bacilli are not. Animal experiments have not been very successful. The bacilli resemble tubercle bacilli very closely, and they also have the appearance of containing spores, but Bordoni-Uffreduzzi contends that these are not spores, but that the bacilli form arthrospores.

Bacillus mallei, B. of glanders (Löffler, Schütz), is the cause of the disease from which it derives its name. It attacks human beings, horses, asses, young dogs, guinea-pigs, and field mice. House mice are not affected, rabbits sometimes, and in one case a sheep was successfully inoculated. After inoculation the wound ulcerates, and the neighboring lymphatic glands enlarge. If the amount inoculated is small, the animal may live several weeks, and one or more joints of the feet may ulcerate. There is also swelling of the testes or of the ovaries and vulva, and ulceration of the nasal cavities.

This organism grows readily upon various media, preferably at temperatures above 25° C., producing a reddish-brown, slimy coating upon potatoes. The bacilli are not unlike tubercle bacilli, but are more uniform in length and thicker. In stained preparations they often look like chains of cocci. They are not easily stained in sections.

Bacillus of Rothlauf, microbe du rouget du porc, etc. (Thuillier, Pasteur, Löffler). Hogs affected with Rothlauf become sick quite suddenly. The temperature rises to 43° C. (109.4°F.), and they have bloody mucous passages. Sooner or later the skin of the abdomen, neck, etc., becomes red, and finally reddish-brown. They die on about the fourth day with paralysis or cramps. Chiefly young hogs from three months to three years are subject to it. The disease is believed by some to start in the intestines from the hogs eating mice or other animals, and fæces containing the micro-organism. On post-mortem examination the mucous membrane of the small intestine is found to be red and swollen, the Peyer's patches and solitary follicles are prominent, and are here and there ulcerated, especially in the neighborhood of the ileo-cæcal valve. The liver and spleen are somewhat enlarged. The lymph-glands, especially of the mesentery, are enlarged and dark red with punctiform ecchymoses; these are also found upon the epicardium of the auricles. The lungs are also filled with blood. The muscles are soft, and of a dirty reddish color. The kidneys are the seat of a hæmorrhagic parenchymatous nephritis.

House mice and pigeons die of septicæmia in forty to sixty hours after inoculations of traces of diseased tissues or cultures. The bacilli are found in all the organs and tissues lying in and among the white blood-corpuscles; the latter are sometimes filled with the bacilli. Guinea-pigs, field-mice, and, to a certain extent, rabbits, are not susceptible, but the latter sometimes have a local inflammation at the point of inoculation, and are then thoroughly protected.

The bacilli are 0.2 μ thick and 0.6 to 1.8 μ long, and probably form spores. They are readily cultivated at various temperatures and upon different media. They stain readily in the ordinary way, and also by Gram's method.

The colonies in gelatine are characterized by a delicate bluish-gray cloud which surrounds the thicker central portion. This cloudy zone is seen under the microscope to consist of a very fine network of delicate threads. Colonies never lie on the surface of the gelatine, but are always found to be in the substance. In stab-cultures the cloud appears all around the line of inoculation;

the most vigorous growth is in the lower parts of the tube.

Bacillus murisepticus was obtained by Koch from mice which had died after inoculations of fluids just beginning to putrefy. It behaves in cultures and inoculations upon animals precisely like the Rothlauf bacillus. It is said to be shorter than the latter.

Bacillus diphtheriæ. Löffler, who discovered this organism, was at first cautious in assigning to it its full importance, because it could not be detected in some typical cases of diphtheria, and because it was always necessary to produce some lesion of the mucous membrane in inoculations upon animals. It is possible, however, that in those cases where it was not found it might have been present in the form of spores or retrograde forms; and as to the latter objection, it may be that in the human being also minute lesions are necessary. Löffler also found the bacilli once in a number of examinations of persons not affected with diphtheria. Still, it is very probable that this organism causes at least one group of diphtheritic diseases.

Rats and mice show no reaction after inoculation. Guinea-pigs and small birds die after subcutaneous inoculation with extensive œdema in the subcutaneous connective tissue around the wound. A very characteristic pseudo-membrane was formed in the trachea of rabbits, chickens, and pigeons, where cultures were applied to the wounded mucous membrane; beside the pseudo-membrane there were also bloody œdema and hæmorrhage in the tissues of the lymphatic glands, and effusion in the pleural cavity. Similar symptoms have been also noticed after inoculations upon the conjunctiva of rabbits, and the vulva of guinea-pigs. Young animals seem to be more readily affected than older ones.

The rods are of very different lengths, and about as thick as tubercle bacilli. They are often curved, with one or both ends enlarged; in the latter case they are dumb-bell shaped; they have no independent motion. In uncolored preparations the poles, and occasionally other parts of the bacilli, are refractive, and these portions are more intensely colored in stained preparations, so that many of the bacilli seem to be composed of a chain of irregularly shaped pieces. Forms of involution are often met with.

Young colonies under the surface are round or oval; under the microscope they are dark-brown, coarsely granular, and their contour is not sharply marked. Superficial colonies are grayish-yellow, with a rough granular surface, and a fine undulating margin. The bacillus grows slowly upon gelatine at 22° C. (71.6° F.). The best nutrient medium for it is a mixture of three parts calf's or sheep's blood-serum, with one part of neutralized veal bouillon containing one per cent. peptone, one per cent. grape-sugar, and 0.5 per cent. common salt.

Bacillus of Syphilis. Lustgarten discovered bacilli resembling tubercle bacilli in sections from syphilitic tissues, by using the following method of staining: Sections remain from twelve to twenty-four hours in the gentian violet stain for tubercle, and are then dipped several times alternately in a 7.5 per cent. watery solution of permanganate of potassium and in dilute sulphuric acid. A bacillus found in smegma preputialis and labialis may be stained in the same way, so that there is as yet no reliable method of applying bacteriology in the diagnosis of syphilis. It does not grow upon any of our media, and is not very abundant in the tissues. The bacilli resemble tubercle bacilli. They are usually embedded in peculiar cells which are large, and either oval or polygonal. It is often necessary to make a number of sections before finding them.

Bacillus choleræ gallinarum, microbe du choléra des poules, chicken cholera; B. cuniculicida, rabbit septicæmia. I describe rabbit septicæmia and chicken cholera together, because they are probably identical. Several authorities have observed the disease in epidemics and in isolated cases, where the animals had taken the disease through accident. Koch obtained the organism from dirty water, and from a piece of foul salt-meat. The smallest trace suffices to kill rabbits, house mice, chickens, pigeons, sparrows, and pheasants. Field mice and guinea-pigs are not susceptible. Animals that have died of it have the bacilli in all the tissues, etc., but not always in abundance. Animals have also been infected by feeding them with cultures.

The bacilli grow readily upon various media. Gelatine colonies, under the microscope, are finely granular, and have a light-yellow centre surrounded by a brown ring and a light peripheral zone.

The bacilli are short and stain at the poles, so that they resemble diplococci. They are about 1.4 μ long and 0.7 μ broad. They sometimes hang together and form short chains, and are often surrounded by a capsule. They stain readily in the aqueous solutions of various aniline dyes, but are not colored by Gram's method.

Bacillus septicus agrigenus was obtained from manured earth by Nicolaier, in Flügge's laboratory. It is like the foregoing, except that it kills field mice.

Bacillus diphtheriæ columbarum was obtained by Löffler from epidemics of diphtheria in pigeons. The disease attacks, preferably, young birds and fancy breeds. The bacilli resemble those of chicken cholera, but are a little longer. This organism grows upon various media. The surface of the potato where it is grown assumes a grayish color, but is otherwise unchanged. The most characteristic feature is that it produces a very peculiar marbled appearance in the liver of mice which have been inoculated with it. In the centre of the white spaces thus marked off in the liver are found intravascular masses of bacteria. The animals die in about five days after subcutaneous inoculations. According to Löffler, the diphtheria of chickens is not caused by the above bacillus, for they are not susceptible to inoculation. Guinea-pigs, rats, and dogs are also unsusceptible.

Bacillus diphtheriæ vitulorum was found by Löffler in diphtheria of calves. Cultures were not successful, but inoculations from animal to animal were. The bacilli are about 0.5 μ broad and about five or six times as long.

Bacillus alvei was discovered by Watson Cheyne and Chesire in the so-called "foul brood" of bees. It is readily cultivated upon various media. The bacilli vary from 2.54 μ to 5.08 μ in length, and are 0.85 μ thick. Some of them have a sluggish motion. They bulge out to a spindle shape and form spores in the enlarged part.

Bacilli are found in infusions of *jequirity* and in inflammations caused by it, but they are probably not the active principle of the drug.

Bacillus tetani was cultivated from garden earth by Nicolaier, in Flügge's laboratory. It is an exquisite anaërobic organism, and cultures inoculated into various animals produce tetanus; but pure cultures have probably never been obtained. The bacilli constantly present are narrow and bristle-like, with a knob at one end. They have no independent motion, are thicker, and about two or three times as long as tubercle bacilli, and are readily stained with fuchsine (Hochsinger).[6] But these bacilli are always accompanied by others, so that it is possible that the tetanus bacillus will grow only in combination with one or more kinds of bacteria; in other words, it may be an example of symbiosis (Flügge). Inoculations of garden earth are sometimes followed by tetanus and sometimes by malignant œdema (see above). Even white rats are subject to infection from inoculations of earth. Inoculations from the diseased tissues of patients dead of tetanus have also been successful. The bacilli are found in the tissue dividing the healthy from the diseased portions, and in the pus. They are rare or lacking in the blood, in the cerebro-spinal fluid, in the substance of the nerve-centres, in liquid squeezed from nerves, and in the internal organs; but subcutaneous inoculations with parts of the tissues surrounding the wounds, and with the purulent secretions rubbed up in water, have been found to produce tetanus (A. Bonome[7]). Inoculations with blood are occasionally successful (Flügge, Hochsinger).

Brieger[8] has isolated a specific ptomaïne (tetanine), along with other toxines, from impure cultures of tetanus bacilli.

Bacillus parvus ovatus, Bacillus of swine plague (Löffler, Schütz, Salmon), was found in a hog that had died

of a disease similar to rouget du porc. It was present in the œdematous skin, in the liver, etc. Mice, rabbits, and guinea-pigs all died after subcutaneous inoculations with bloody œdema of the subcutaneous connective tissue and red patches in the lungs, etc. A hog was successfully inoculated. Rats were not affected.

The bacilli are readily cultivated upon gelatine, etc. They are found in enormous quantities in the tissues, and are about half as large as rabbit septicæmia bacilli, but resemble the latter sometimes. They are ovoid in shape.

Löffler[9] found that the principal lesions were situated in the intestine and skin. Schütz[10] found in his cases that the respiratory organs were mainly affected, and succeeded in producing the disease by inhalations of cultures. Salmon[11] has described two diseases: One, in which the intestines are principally involved, he calls *hog cholera;* the other, in which the lungs are affected with multiple pneumonia, he calls *swine plague;* in the latter disease the intestines are sometimes unaffected.

Smith has found that cultures from the spleens of hogs which had died of swine plague in Nebraska, differed from those from other sources by forming a skin on the surface of liquid media, by forming a denser mass at the bottom of the test-tube, by not growing in neutral gelatine, and by not being pathogenic for guinea-pigs.

Bacillus necrophorus was obtained by Löffler from inoculations of bits of condylomata into the anterior chamber of rabbits' eyes. The animals died in about eight days with caseous necrosis around the wound, isolated pneumonic foci with hæmorrhage, or necrosis of large portions of the lungs, and foci in the heart. Rabbits inoculated on the ear are similarly affected. Mice are also susceptible to the disease when inoculated.

The bacilli refuse to grow upon ordinary gelatine, etc., and are best cultivated in neutralized rabbit bouillon, though they grow in chicken bouillon and upon blood-serum from the horse. They make a downy, fluffy mass around any bits of tissue which have been introduced into the liquid media above referred to. They are quite narrow and vary in length, but are usually long and wavy. In cultures they often have swollen and refractive spots when examined on a cover-glass unstained, but the latter are probably not spores.

Bacillus cavicida, Brieger's bacillus, was obtained from human fæces. It kills guinea-pigs, when inoculated in traces under the skin, inside of seventy-two hours without exception. Rabbits and mice are for the most part insusceptible. It produces violent inflammation of the small intestine. The individual bacilli are very small; they grow upon gelatine, etc. The surfaces of colonies on gelatine are divided up by fissures running irregularly in all directions, so that they resemble the back of a terrapin.

The four following bacilli, like some of the preceding, produce extensive disturbances of the alimentary tract when injected into the veins of animals. But those which have been already treated of are more or less active in minute quantities. The following group can hardly lay claim to pathogenic power in the sense of multiplying in the body, causing necrosis of tissue, stopping up the capillaries, etc.; they act by intoxication. They possibly multiply in the body if they are introduced in such large quantities that the organs can no longer resist, but the death of the animal is clearly due to poison, either introduced in inoculation or subsequently produced. Injections of smaller quantities produce the same symptoms in a modified form. Furthermore, the same effects are produced by injections of sterilized cultures, *i.e.*, where the bacteria have been killed but the products of growth are not destroyed. This production of intestinal disturbance, vomiting, dysentery, etc., also follows injections of large quantities of various organisms, even of some of those which have come to be regarded as distinctly pathogenic; but some of the pathogenic organisms show no such action, and even in large quantities produce no effect except the characteristic symptoms of the peculiar disease.

Bacillus oxytoxicus perniciosus was obtained from milk by Wyssokowitsch, in Flügge's laboratory. It is a short, thick bacillus, and produces the gastro-enteric disturbances above described. It grows upon various media.

Bacillus Neapolitanus was obtained by Emmerich from the fæces and organs of cholera patients. Emmerich claims that it is the cause of Asiatic cholera, but his proofs are not conclusive, and he has found but few followers. It very much resembles the typhoid-fever bacillus in cultures and under the microscope, except that on potatoes it has a brownish-yellow, oily, slimy growth. The symptoms following inoculations are as above. As Weisser has found "that in human fæces, normal as well as abnormal, in the air, in putrefied fluids, bacteria are present which are identical with the so-called Neapolitan cholera bacteria in their morphological character, biological function, and pathogenic action,"[12] there is every reason to believe that Emmerich was mistaken in claiming that his bacterium is the cause of Asiatic cholera.

Bacterium coli commune and *Bacterium lactis aërogenes*[13] were found constantly in the fæces of milk-fed infants, and these bacteria were found alone as long as the infants were healthy. They constitute, therefore, a most important diagnostic sign. In proportion to the extent and severity of gastro-enteric disturbance the two organisms become more and more displaced by other bacteria. It is advisable to isolate the two bacteria from the fæces of a healthy breast-fed infant a few hours after birth, and use the cultures for comparison in other cases. The fæces should be obtained by introducing a sterilized glass tube into the rectum, and inserting a second smaller tube or a platinum loop inside of the first. Bacterium lactis aërogenes is found in large numbers in the upper part of the intestines, but in the lower part it becomes rare or even absent, and its place is occupied by the colon bacterium. Plates from the fæces seem at first glance to contain colonies of the colon bacterium alone, but there are always some colonies of the other.

Bacterium lactis aërogenes is 0.5 to 1.0 μ in thickness and about twice that in length. Its growth on all the media resembles that of Friedländer's pneumococcus (B. Pneumoniæ), except that in stab-cultures the growth along the line of puncture is more vigorous in the deeper parts, and often consists of a line of large, isolated, round masses. It also forms gas-bubbles on potatoes.

The bacterium coli commune is about 0.4 to 0.6 μ thick, and varies in length up to 3 μ and more. It has independent motion and is not colored by Gram's method. The deeper colonies in gelatine are yellow and granulated, the superficial colonies are spread out and are regularly granulated or folded into radiating lines.

Both coagulate milk, but the B. lactis aërogenes seems to have more energetic power; it produces coagulation and the formation of lactic acid in about twenty-four to forty-eight hours, whereas the colon bacillus requires a longer time. They both cause a fermentation in solutions of grape-sugar; the bacterium lactis aërogenes also causes fermentation in milk-sugar. Experiments upon animals are essentially as above.

THE SPIRO-BACTERIA.—*Comma bacillus, spirillum choleræ asiaticæ,* was discovered by Koch, in 1883. It is always found in Asiatic cholera and never in any other disease, nor in healthy persons. The bacilli are sometimes met with almost unmixed with other bacteria in the intestines, especially in the lower part of the small intestine, where the cholera lesions are greatest. They are found, furthermore, occasionally in the gall-bladder and vomit. They are not present in the tissues, except in the intestinal wall.

A process similar to cholera asiatica has been produced by injecting a few drops of a bouillon culture of the comma bacilli into the duodenum of guinea-pigs. Under ordinary conditions the organisms cannot pass through the stomach, because they are destroyed by the gastric juice; but if the stomach of a guinea-pig is made alkaline with about 5 c.c. of a five per cent. solution of soda, it remains so for several hours, and the organisms are not destroyed. It therefore becomes necessary, in order to infect guinea-pigs per os, to make the stomach alkaline, but it is also requisite to administer opium in some form so as to check intestinal peristalsis. Guinea-

pigs treated either by injections into the duodenum, or by the introduction of cultures into the stomach, prepared as above, generally die with symptoms very much resembling cholera in man. But simple injections into the duodenum are not sufficient, for unless the intestine is somewhat roughly handled it does not react ; it seems necessary that there should be more or less bruising of the tissues.

The bacilli are generally curved in the direction of the long axis, sometimes hanging together, forming a long or short spiral thread. The separate "commas" vary in length from 0.8 μ to 2 μ, and are about one-sixth to one-third as thick. Many of them are straight, especially in stained preparations. They possess independent motion. They may be colored with various dyes, but are not colored by Gram's method.

Colonies on gelatine at 22° C. (71.6° F.) in twenty-four hours are little white points ; at this stage they appear under the microscope round, light-yellow, with an uneven, wavy outline and surface. They soon assume a glistening appearance, so that plate-cultures appear as if sprinkled with pulverized glass. The gelatine around each colony is liquefied to a slight extent. The liquefaction is not very rapid. In stab-cultures it liquefies all along the line of inoculation in two days, forming a funnel-like depression in the upper part of the gelatine. In this funnel-like depression there is generally the appearance as if an air-bubble were shut off in its upper part. The liquefaction finally extends till all the gelatine is liquefied. It only grows at 30° to 35° C. (86° to 95° F.) on potatoes, forming a light-brown, slimy coating, which afterward changes to a grayish-brown.

Spirillum of Finkler and Prior, and spirillum tyrogenum (Deneke). These two organisms are of interest merely because of their resemblance to the cholera organism. Finkler and Prior's organism was first found in the dejecta which had been kept for some time from cases of cholera morbus. Deneke's organism was found in old cheese. The bacilli of the former are longer and thicker than the cholera bacilli, and are somewhat pointed at the ends. Deneke's organism is a trifle smaller than the cholera organism, and the curve is sharper. The spiral threads of cholera are shorter than those of Deneke's organism, and longer than those found in Finkler-Prior's organism. The colonies in gelatine of Finkler and Prior's spirillum, and of Deneke's also, have a sharp, smooth edge, and are dark colored. Finkler and Prior's organism liquefies very rapidly, and Deneke's occupies the middle place in this respect ; it liquefies much more rapidly than cholera, but less so than Finkler and Prior's. Finkler and Prior's organism grows readily at low and high temperatures on potatoes, and Deneke's refuses to grow upon potatoes at any temperature. Neither of them seems to have as marked pathogenic properties as the cholera organism. Cholera bacilli are killed by drying, they require some moisture ; whereas Finkler and Prior's bacilli may be thoroughly dried and retain their vitality for months. The addition of hydrochloric or sulphuric acid to a pure culture of the cholera spirillum produces a bright-red color (Bujwid).

Spirillum Obermeieri. Long spiral threads, 16 to 40 μ in length. They are readily stained. Only found in the blood during the fever in cases of relapsing fever. They have never been cultivated. Apes and human beings have been successfully inoculated subcutaneously with a small quantity of fresh blood from a patient suffering from an attack of the fever. It is only during the fever, when the spirilli are present, that the inoculations are successful.

UNCLASSIFIED MICRO-PARASITES.—*Actinomyces*, or ray parasite, causes the disease from which it derives its name. It is found in diseased foci in the tongue, jaw, lungs, etc., of cattle, producing in these animals the disease known as "swelled head." The parasite is also capable of infecting human beings. Under the microscope the parasite is seen to consist of a mass of club-shaped branches, more or less radiating from a central point. Boström claims to have succeeded in making cultivations by taking a portion of tissue containing the organism, and allowing it to remain a few days in nutrient gelatine. He then took it out, and pressed it between two glass plates, so as to break it up, and inoculated it upon agar and blood-serum. He found that the club-shaped extremities of the branches were not capable of growth, and regards them as forms of involution. The central mass, composed of branching threads, grew well upon gelatine, etc., in the form of reddish-yellow knobs, with finely feathered margins and feathery projections. Old colonies are feathery all over. Cultures were said to be successfully inoculated upon animals.

It is not decided whether this organism belongs to any of the classes described, but it is considered by Boström to belong to the higher form of bacteria.

The *protozoa* are attracting ever-increasing interest from the fact of their occurrence in certain diseases. Since the investigations of Laveran, who first observed *the malarial parasite*, Marchiafava and Celli, Councilman and Osler, have all been able to find protozoic organisms constantly present in the blood from malarial patients.

Protozoa in malaria.

Dr. Councilman's investigations are still in progress, but he has already established the following important facts : He divides the forms in which the organism occurs into two classes, the intracorpuscular forms and the free forms. The former are always found where the symptoms are of an intermittent type. They vary in size and appearance. The smallest of them are simply small hyaline protoplasmic masses in active amœboid motion, contained in the red blood-corpuscles. They are not easy to see, because they differ so slightly from the surrounding protoplasm. They increase in size till they finally fill the blood-corpuscles in which they lie. They also become pigmented at the expense of the hæmoglobin of the latter ; the red corpuscles becoming paler as the pigmentation of the organisms increases. Just before, or during, a chill the latter lose their hyaline appearance, and become coarsely granular ; and the pigment, which up to this time is arranged in fine rod-like masses, becomes collected in the interior of the body. The protoplasm finally breaks up into the small round bodies mentioned at first. These are liberated along with the pigment. The latter is soon taken up by the white blood-corpuscles. This segmentation is so characteristic that a chill may be diagnosed with certainty two or three hours in advance.

The free forms, on the other hand, are met with in malarial cachexia. They vary in shape. Most of them are crescentic, but round and oval forms are also met with. These have highly refractive edges and a mass of pigment in the middle. The crescents are about once and a half as long, and one-third as broad, as the diameter of a blood-corpuscle.

But besides these forms is another, to which Councilman attaches most importance. This is a body about the size of a blood-corpuscle, and containing pigment granules in active motion. Attached to the body are one or more narrow filaments three to six times as long as the diameter of a blood-corpuscle. These filaments are in active motion, and have little nodular swellings at various points ; they also occur detached from the bodies above described. These filamented bodies are not often seen, but may be found in any of the forms of malarial infection.

The blood drawn from the spleen always contains a greater number of organisms, especially the flagellated forms, than the blood drawn from the finger. And it is a very interesting fact that the intracorpuscular forms disappeared from the blood when forty-five grains of quinine were given for two successive days ; whereas the other forms were only slightly, or not at all, affected by the same amount of quinine.

But the protozoa very probably cause *epidemic dysentery* also. After they were observed by Koch in ex-

Protozoa in dysentery.

cretions from the intestines of persons who had died of dysentery in the tropics, Kartulis found that amœbæ were constantly present in this disease in Egypt, and emphasized their pathogenic power. Finally, Uplavici, after holding the opinion for a long time that dysentery is a mycotic disease, convinced himself that it is caused by amœbæ in Europe also.[14]

Modes of Accidental Infection.—The study of micro-organisms has thrown much light upon the way in which infection takes place in nature. Some organisms are capable of causing only diseases of the intestines; another finds conditions favorable to its growth in the animal body only upon the mucous membrane of the urinary organs, etc., of human beings; others produce disease when introduced merely under the skin; and still others require to be deeply inserted, etc.

But in many cases the mere presence of the organism is not sufficient to produce disease, there must be, besides, a predisposition on the part of the animal. It has been already stated that the spores of the anthrax bacilli, when taken in with the food and drink, cause the disease to start from the intestines, whereas the anthrax bacilli, when free from spores, are destroyed by the action of the digestive juices. From these facts it is apparent that, on the one hand, the power of resistance offered by an organism to the action of the gastric juice, and, on the other hand, the condition of this juice—as, for example, the degree of acidity of the gastric juice—are important factors to be considered when infection occurs through the alimentary tract. Vegetative bacterial cells are probably in most instances killed by the action of the normal stomach, so that, before there can be infection beginning in the intestines with non-spore-bearing bacilli, or with cocci, the function of the stomach must become impaired. It follows that all circumstances which impair the digestion are predisposing causes of infection. Experience has shown that what is popularly and vaguely described as a lowering of the tone or vitality of the body, whether by unhygienic modes of life or by disease, is, in the case of many infectious diseases, an undoubted predisposing factor. Furthermore, there are often local predisposing causes of infection, such as abrasions, existing foci of disease, the presence of stagnating blood or other fluids, the existence of so-called dead spaces in wounds, etc. These local predisposing influences are of special importance in favoring infection with organisms which cause suppuration.

Heredity acts in most cases merely as a predisposing cause of disease. In some cases there is a direct transmission of the organisms from the mother to the offspring (see Bacillus of Sympathetic Anthrax), but this is exceptional, and generally, when the influence of heredity is apparent, the offspring inherit a want of resisting power which need not be manifested by any anatomical peculiarities, and they are liable to become infected at an early period of their existence. If such offspring are placed under conditions favorable to their vigorous development, the inherited predisposition may undoubtedly in many cases be overcome.

Although we are able in some instances to point out the nature of the predisposing factors, such as those already mentioned, it must be admitted that our knowledge on this point is very imperfect, and that while we are compelled to recognize the importance of predisposition as an etiological factor, we cannot define the nature of this element. It is a curious fact that many races of animals have immunity from certain infectious diseases as a specific characteristic; thus Algerian sheep, rats, and dogs are scarcely susceptible to anthrax (see also Mouse Septicæmia, Glanders, etc.). Animals may acquire immunity from a disease by having suffered once from an attack of the same. Upon this rests the theory of preventive inoculation. It has already been mentioned that Pasteur was able to modify the virulence of certain organisms to such an extent that their inoculation produced no apparent effect, and by carefully regulating this process of attenuation he—and others after him—have been able to produce such a modification of the virus that it is capable of producing only a mild disease, which is followed by protection of the animal from infection by the virulent organism. It has also been claimed that inoculation with the poisonous products, or ptomaïnes, produced by a virulent micro-organism, may be followed by protection from infection by the organism; although this view has been advocated by Pasteur, as regards the protective inoculations against hydrophobia, it cannot be considered as proven.

Pasteur's anthrax vaccine is obtained by subjecting cultures to temperatures varying from 42° C. to 55° C. for a length of time, varying in inverse proportion to the temperature. According to Toussaint, an exposure to 55° C. for ten minutes; according to Pasteur and Koch, one to 42° C. for twenty-eight to thirty days, suffices to deprive the living bacilli of all pathogenic power. Chicken cholera, sympathetic anthrax, and Rothlauf cultures have all been modified in different ways, so that they could be used for protective inoculations.

The organism of rabies has not been isolated, but Pasteur makes inoculations with parts of the spinal cord of rabbits which have been previously inoculated from the spinal cord of a rabid dog. If pieces of the spinal cord of an animal dead from rabies are kept in dry air, they gradually lose their virulence, till after seven days they can no longer produce the disease in rabbits.

There is no doubt that preventive inoculations are possible, but the methods have not yet been so perfected as to be of much practical use, or to find universal adoption.

In summing up the factors which produce infection, it is seen that natural, or acquired, predisposition is an essential condition. The organisms may gain access to the body in various ways. They may be introduced with the food and water into the alimentary tract, or they may be inhaled, or they may find their way through lesions in the skin, or they may enter the genito-urinary tract.

As milk is not generally boiled, *i.e.*, sterilized, it affords a most dangerous vehicle of infection, along with all those articles of food which we are accustomed to use in an uncooked state, and those, too, which are left standing to be eaten cold. Such articles may easily become contaminated, and serve as an excellent nutrient material for micro-organisms. Water plays an important part, but since the pathogenic micro-organisms which have been tested do not multiply, or do so only to a limited extent, and for a limited time, in this medium, the danger of infection from drinking-water has often been exaggerated. This is less true, however, for sewage-water.

Infection from unintentional contact with pathogenic micro-organisms, and from want of cleanliness, probably occurs much oftener than has been generally supposed. Infection from the air, on the other hand, is probably less frequent than is usually stated, for micro-organisms are specifically heavier than air, and many of them are destroyed by drying. Unless they are dry, it has been shown that they cannot be taken up into the air. Insects may doubtless be carriers of contagion. The wound made by a mosquito, which has a short time before fed upon a diseased animal, would appear to be a most perfect inoculation.

Mode of elimination from the body.

The mode by which pathogenic micro-organisms are eliminated from the body is doubtless of great importance in determining the degree of contagion of infectious diseases. It has been shown by the experiments of Wyssokowitsch that many micro-organisms are destroyed within the body, and that in general they are eliminated only from excretory organs which suffer characteristic lesions from the presence of the organisms. It is apparent that when the specific micro-organisms are eliminated from the body only by the intestinal excreta (cholera, typhoid fever), direct contagion is much less likely to occur than when the organisms are thrown off from the skin (variola, scarlatina, etc.). If the organism is not discharged at all from the body, as seems to be the case with malaria, direct contagion cannot well occur.

Mode of action of pathogenic bacteria.

We possess little positive knowledge as to the mode of action of pathogenic bacteria. Doubtless this action varies with different species of bacteria. In this connection the investigations, particularly those of Brieger, are of interest which have demonstrated the production by bacteria of poisonous substances, obtained as crystallizable alkaloids, and known as ptomaïnes. Thus Brieger has obtained from impure cultures of the tetanus bacillus various alkaloidal sub-

stances which, injected into animals, produce symptoms resembling tetanus (see p. 339). It is believed that the cholera bacteria also act through the agency of ptomaïnes. Other injurious effects attributable to the action of bacteria are various local lesions, such as inflammation, necrosis, hæmorrhages, occlusion of blood-vessels and lymphatics, etc. In certain diseases the bacteria are present in the blood and other tissues in such enormous numbers that there is reason to believe that they may destroy life by the appropriation, at the expense of the body, of nutriment, particularly of oxygen.

On the other hand, much interesting work has been done to determine in what way the animal body reacts against the attack of micro-organisms. Metschnikoff[15] holds that the white blood-corpuscles eat up the bacteria. This view is based upon experiments in which he inoculated frogs and other animals with anthrax bacilli. He found in the warm-blooded animals which were susceptible, that when virulent material was used only a few leucocytes took up the bacilli. But, on the contrary, when attenuated virus was used, or when the animals were insusceptible (white rats, frogs, and a rabbit, which was found to be immune), the leucocytes take up nearly all the bacilli. This may occur at the seat of inoculation, in the blood and in various organs, particularly the spleen and the liver. The time required for the leucocytes to take up the bacilli was found to vary in different cases. Moreover, after the bacilli were taken up by the leucocytes, it was observed that the former degenerated and died. These experiments were repeated and supplemented by Hess,[16] who was able to substantiate Metschnikoff's observations. Besides inoculations in the usual way, Hess made use of a Ziegler cell. This cell consists of a cover-glass cemented to a slide of equal size, so that there remains a capillary space between, open upon one side. Hess inoculated cells of this sort with anthrax bacilli, and inserted them under the skin of various animals. He noticed, in the case of immune animals, that the redness and œdema at the point of insertion were much more marked than in the case of susceptible animals. After allowing the cells to remain various lengths of time, Hess removed them, and examined them immediately with the microscope. He then allowed them to dry, and stained them without first passing them through the flame. He found that in immune animals most of the bacilli had been taken up by the white blood-corpuscles, and were more or less broken up; the relatively few bacilli which had not been taken up by the leucocytes were unchanged. The bacilli contained in leucocytes were never found in chains, they were always separate bacilli. This, in brief, is the *phagocytosis* hypothesis, and it seems very plausible; for it is well known that the leucocytes take up pigment granules, etc. But some observers (Wyssokowitsch, Flügge, Hanau, Klebs) have come to quite different conclusions. They have not been able to find the leucocytes loaded with bacteria in such relatively large numbers as have Metschnikoff and Hess, and where they have found them they contend that the bacteria have attacked the leucocytes, and not the reverse.

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Meade Bolton.

[1] Paul Liborius: Zeitschrift f. Hygiene, Bd. I., p. 115, 1886.
[2] Friedländer: Microscopische Technik, Berlin, 1884; translated by Coe.
[3] Zeitschrift f. Hygiene, Bd. II., p. 234 et seq.
[4] See Bender et al. in Centralblatt f. Bact., etc., Bd. I., p. 563 and 236.
[5] Zeitschrift f. Hygiene, Bd. I., p. 178 et seq.
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[7] Bonome: Fortschritte d. Medicin, November 1, 1887, p. 690 et seq.
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[12] Zeitschrift f. Hygiene, Bd. I., p. 362, 1886.
[13] Escherich: Centralblatt f. Bacteriologie, etc., Bd. I., p. 705 et seq.
[14] Virchow's Arch., Bd. CV., Heft 3; also, Centralblatt f. Bacteriologie, etc., Bd. I., p. 537 et seq.
[15] Virchow's Archiv f. Path. Anatomie, Bd. XCVI. u. XCVII.
[16] Ibid.: Bd. CIX. u. CX.

SCHLANGENBAD is a thermal spa in Hesse-Nassau, Prussia. It lies in a picturesque valley at an elevation of about 1,000 feet above the sea. The water contains a very small proportion of mineral constituents, chiefly sodium chloride and sodium carbonate. The temperature of the different springs varies between 83.5° and 92° F. The water is used chiefly for baths, though it is also employed occasionally for drinking. Employment is also made of goats' milk, whey, and herb juices. Schlangenbad is visited chiefly by women suffering from uterine troubles, and from excessive nervous irritability. The season extends from the middle of May to the first of October. *T. L. S.*

SCHOOLEY'S MOUNTAIN SPRINGS. *Location and Post-office*, Schooley's Mountain, Morris County, N. J.

ACCESS.—By the Delaware, Lackawanna & Western Railroad to Hackettstown, thence by stage two and one-half miles to the springs.

ANALYSIS (C. McIntire, Jr.).—One pint contains:

	Grains.
Carbonate of soda	0.072
Carbonate of magnesia	0.200
Carbonate of iron	0.072
Carbonate of manganese	trace
Carbonate of lime	0.178
Chloride of sodium	0.054
Sulphate of lime	0.210
Alumina	0.018
Ammonia	trace
Silicic acid	0.092
Total	0.896
Carbonic acid gas	not determined.

THERAPEUTIC PROPERTIES.—This is a very mild alkaline-chalybeate-carbonated water. The small proportion of salts which it contains, together with the carbonic acid gas, renders it a very pleasant and efficient tonic. The discharge is small, about thirty gallons per hour. The temperature is 50° F.

These springs are situated among the mountains of Northern New Jersey. They have long been a popular summer resort, on account of the beauty and healthfulness of their surroundings and their accessibility. There are several well-appointed hotels.

George B. Fowler.

SCHWALBACH is a spa situated in the province of Hesse-Nassau, Prussia. It lies in the valley of the Münzenbach, about twelve miles from Wiesbaden, and five miles from the health-resort Schlangenbad. Its elevation is 972 feet above sea-level, and as it is well protected against all but the southerly winds, its climate is mild and well suited for invalids. There are eight mineral springs at Schwalbach, known as the Wein-, Stahl-, Rosen-, Paulinen-, Ehe-, Neu-, Linden-, and Adelhaid-Brunnen. There is but little difference in the composition of the waters of these springs. The following is the

analysis of two of the springs, as made by Fresenius. In 1,000 parts there are, of

	Wein-Brunnen.	Linden-Brunnen.
Ferrous bicarbonate	0.057801	0.009902
Manganous bicarbonate	0.009085	0.004680
Sodium bicarbonate	0.245345	0.042317
Calcium bicarbonate	0.572129	0.429277
Magnesium bicarbonate	0.605120	0.395267
Ammonium bicarbonate	......	0.002205
Lithium bicarbonate	......	0.002033
Strontium bicarbonate	......	0.001048
Sodium chloride	0.008630	0.017622
Sodium sulphate	0.006193	0.016156
Potassium sulphate	0.007469	0.006414
Sodium nitrate	......	0.005541
Sodium phosphate	trace	0.000438
Aluminium phosphate	......	0.000197
Silicic acid	0.046500	0.032821
Organic matter, etc	0.000046	0.000003
Total solids	1.558318	0.965921

The gases are carbonic acid and a very small proportion of sulphuretted hydrogen.

Schwalbach is a favorite health-resort, and is visited by several thousand guests every year. The diseases for the relief of which a course of treatment at this spa is recommended are anæmia and chlorosis, epilepsy, chorea, progressive muscular atrophy, neuralgia, neurasthenia, hysteria, and other functional and organic nervous disorders, Bright's disease, diabetes mellitus, chronic vesical catarrh, and various affections of the female sexual organs.

The waters are employed externally and internally, according to the individual indications, and facilities are afforded for pine-needle, mud, vapor, and other baths. The season lasts from May to October. There are excellent accommodations for visitors. *T. L. S.*

SCIATICA. Etiology.—Sciatica differs from the large majority of neuralgias in the fact that it comparatively seldom results from constitutional conditions.

According to most writers, it is much more frequent in men than in women. Among 53 of my own cases, 39 occurred in males, 14 in females. Erb reports 40 males, 10 females; Eulenburg, 54 males, 17 females. Arnoldi is the only one of large experience who arrives at other results. Among 338 cases he found 172 males and 166 females. This experience is entirely exceptional, and undoubtedly does not hold good for the general run of cases.

Sciatica is a disease of middle and advanced life. Among my 53 dispensary cases 1 was twelve years of age; 7 were between twenty and thirty years of age; 10 between thirty and forty years; 18 between forty and fifty years; 7 between fifty and sixty years; 7 between sixty and seventy years; and 3 between seventy and seventy-five years of age. If we take into consideration the rapidly diminishing number of people after the age of fifty years, it is evident that the disease grows relatively more frequent beyond this period of life. Prior to the age of early manhood, sciatica is one of the most infrequent of all forms of neuralgia, and it began at this time in only one of my cases. Caussays reports two cases at the ages of seven and eight years, respectively.

The ordinary predisposing causes of neuralgia have comparatively little influence on the development of sciatica. This is particularly true of heredity, usually so potent in the etiology of neuroses. Very many writers ascribe no influence whatever to this cause, and Anstie appears to be almost the only writer who attaches any importance to it. In my own experience, a few cases have occurred in which the disease appeared to alternate with other forms of neuralgia, or in which the patients had suffered, at some previous time, from other neuroses; but, on the whole, the neuropathic influence appears to have had very little to do with the etiology of the affection.

Anæmia and other conditions of exhaustion likewise have less effect in the production of sciatica than in that of other neuralgias. The patients are often in perfect health at the onset of the attack, but the latter often has a depressing effect on the general condition if the pain continues severe for a long time. In a considerable number of cases, however, the sciatica begins at an advanced age, when the tissues of the body have begun to undergo senile involution. Anstie lays stress upon the fact that the disease is frequent in those who break down at an early period in life, although they may present the outward appearances of excellent health.

The disease has long been supposed to be intimately related to rheumatism—in the narrow as well as in the more vague and wider sense—but the fact of such connection is by no means well established. It is true that many of the patients suffer at times from muscular rheumatism, that sciatica begins not infrequently with an attack of lumbago, and that the supposed causes of "rheumatism" act unfavorably in sciatica; but further than this nothing can be said of the connection between the two diseases.

The term "gouty sciatica" is sometimes applied to the disease when it occurs in gouty subjects, and it is said, at times, to take the place of the ordinary gouty paroxysm. It is doubtful, however, whether sciatica, when it occurs under such circumstances, should not be attributed to the portal congestion, constipation, and hæmorrhoids which are so common in gout.

Infectious diseases are an infrequent cause of sciatica. Syphilis is probably the most important factor in this category, but it is likewise a rare cause. Sciatica may develop during the early or later stages of constitutional syphilis, and may or may not be associated with the formation of gummata along the course of the nerve, or in the surrounding tissues. This form is characterized by the tendency to nocturnal exacerbations, and by its ready amenability to antisyphilitic treatment. We must exercise caution here, however, inasmuch as non-specific sciatica occasionally acts in the same way, and the suspicion of the specific origin of the disease cannot be made a certainty unless other evidences of syphilis are present. R. W. Taylor, who has gone exhaustively into the literature of syphilitic sciatica, has been able to find very few authentic cases. He reports four personal cases, in one of which sciatica developed during the first year after inoculation; in the second it was associated with gonorrhœal rheumatism and epididymitis, and was only complicated with syphilis at a subsequent period; in the third it followed extensive gummata and hemiplegia; in the fourth there was gummous infiltration in the gluteal region, probably producing compression of the nerve. It is not certain, from the history of the latter case, that the pain was really neuralgic.

Malaria is also an infrequent cause of sciatica. Cases have been published in which the neuralgic attack replaced the malarial paroxysm. In these cases the pain is sometimes confined to a small branch of the nerve.

A number of cases have been reported after typhoid fever, especially during the period of convalescence. In one of my patients the neuralgia began during convalescence from diphtheria, and proved unusually intractable to treatment.

In rare cases sciatica is one of the symptoms of lead or mercurial poisoning. Although I have seen pains in the lower limbs develop under such circumstances, no case of genuine sciatica due to this cause has come under my observation. I have seen violent sciatica so often in cases of acute alcoholism that the question has arisen whether there is not some causal relation between the two conditions. But alcoholism may be attended with so many unknown factors which might give rise to sciatica (exposure, compression of the nerve, injury, etc.) that I have not been able to arrive at a positive conclusion.

External agencies, such as muscular effort, traumatism, and exposure, possess an unusual degree of influence in the development of sciatica as compared with other neuralgias. The disease is much more frequent in New York City during the damp, wet months, and a relapse is also much more apt to occur at such times. For this reason it is not uncommon among laborers who work in ditches, cab-drivers, and others whose occupation necessitates constant exposure in all weathers.

Muscular effort is sometimes the only ascertainable cause of the disease. In some instances it follows the muscular strain at once, and may begin with its full severity. An instance of this kind has come under my observation.

Injuries, in the shape of blows, falls, gunshot wounds, etc., may give rise to sciatica, as well as to other forms of neuralgia. We may also include under this heading all cases in which the disease results from pressure due to local processes in any part of the course of the nerve, from its spinal origin to its terminal branches. Among these may be mentioned the following: Spondylitis deformans, cancer of the vertebræ, gummata of the dura mater, neuromata within the spinal canal, intrapelvic tumors, the use of forceps during delivery, exudations into the broad ligaments, accumulation of hardened fæces in the rectum, pressure upon the nerve by a popliteal aneurism, neuromata, syphilitic and other tumors of the nerve or adjacent parts, etc.

In very many cases sciatica is associated with chronic constipation and hæmorrhoids. In such cases it is probable that the dilatation of the hæmorrhoidal veins is a potent etiological factor. In a patient under my observation at the present time, the disease developed under these circumstances, the venous congestion being still further increased by dilatation of the heart.

Sciatica is sometimes seen during the course of diabetes, and is then bilateral. Some authors have also noticed that temporary glycosuria may develop during an attack of sciatica.

In rare cases sciatica is the result of reflex irritation. It may accompany various affections of the bladder and uterus, orchitis and epididymitis, stricture of the urethra, or worms in the intestines. Gonorrhœa plays the most important part among this class. It is often complicated with gonorrhœal rheumatism, but sometimes alternates with the latter affection.

But when all is said, we meet with not a few cases in which the most patient examination fails to reveal the cause of the malady.

Clinical History.—Sciatica is usually preceded by prodromal manifestations, though it sometimes begins suddenly with full severity. Thus, an individual bending over to lift a heavy weight may be seized with the pain along the course of the nerve before he has time to straighten up. In the large majority of cases, however, acute pain does not begin at once. The disease is often preceded—sometimes for quite a long time—by an attack of ordinary lumbago. Gradually the pain spreads to the upper and back part of the thigh, at the same time losing its myalgic character and becoming sharp and paroxysmal. The limb often feels weak before the pain has attained any notable intensity. Perhaps there is slight numbness, or a feeling of coldness or weight in the limb. After a variable length of time the severity of the pain increases, and finally the paroxysms may become intolerable in their intensity. When this stage is reached the limb is usually held in a characteristic position. The thigh is somewhat flexed on the abdomen, and the leg on the thigh; the heel is raised from the floor. A corresponding position is assumed in bed, the limb being usually supported upon the opposite one. In walking, the limb is moved stiffly and gingerly, the weight being borne as much as possible on the opposite limb.

The duration of the disease may vary from a few days (rarely less than a week or two) to twenty or thirty years.

We will now enter upon a more detailed consideration of the symptoms.

Sciatica not only occupies a somewhat isolated position among neuralgias as regards etiology, but the pain also differs in certain respects from that of other neuralgias. The severity of the pain is generally moderate, though in some cases it is unendurable, so that the patient writhes upon the bed and screams out in agony. As a general thing, however, the sufferer keeps as quiet as possible, with the thigh flexed on the abdomen and the leg on the thigh. But he is often unable to maintain one position for any great length of time, on account of an intolerable restlessness in the limb. The pain is generally most severe in the back of the thigh and the region of the hip. At the height of the paroxysm it is apt to radiate into the area of distribution of the crural nerve, more rarely into that of the lumbo-abdominal nerve. The crural pain is sometimes hardly exceeded in violence by the sciatic pain itself. The distribution of the nerve to the leg and foot may alone be affected in some cases, and among others of the kind which have been reported we have also seen a case in which the pain was confined to the sole of the foot (plantar neuralgia).

The pain is of a shooting character, apparently from above downward in the majority of cases, though it is difficult for the patient to determine its direction. But the disease differs markedly from other neuralgias in the fact that there are usually pronounced and constant pain and tenderness along the course of the nerve. This steady pain is sometimes extremely annoying. The tenderness is not confined to the painful points (puncta dolorosa), but seems to be located along the entire course of the nerve. The following are the locations of the painful points: 1, A gluteal point, beneath the gluteal fold, midway between the trochanter major and tuber ischii; 2, a point at the emergence of the nerve from the sciatic foramen; 3, a point at the posterior superior spinous process of the ilium; 4, one or two popliteal points at either side of the popliteal space; 5, a fibular point behind the head of the fibula; 6, two malleolar points, one at the posterior part of each malleolus.

The motor symptoms consist of paresis and spasms of the limbs. After severe sciatica has lasted for some time, the muscles of the entire limb undergo a certain degree of atrophy, and in a couple of months the circumference of the thigh and calf may be nearly an inch less than that of the corresponding parts of the other limb. This appears to be the result of the relative disuse of the limb, as is shown by the fact that the muscles supplied by the anterior crural nerve are also wasted. In rarer cases the limb undergoes a certain degree of rapid atrophy which is not explicable in this manner, and is usually attributed to an implication of the trophic fibres of the nerve in the neuralgic process, or to a reflection of the irritation to the large ganglion-cells in the anterior horns of the spinal cord, from which the nerve takes its origin.

In walking, the patient favors the affected limb as much as possible, and holds it quite stiffly on account of a slight degree of contracture of the muscles. It has seemed to me that the limb, as a general thing, is really weaker than its fellow, and that there is not merely apparent weakness due solely to the severity of the pain excited by movement.

Motor spasms do not play a very prominent part in the history of the disease. Patients sometimes tell us that they suffer, especially at night, from cramps in the calf of the leg, and in rarer cases from twitchings of the entire limb.

C. Handfield Jones has reported a peculiar case of left sciatica of ten years' standing. At first the knee-jerk was absent in both legs. After a time it appeared in the right leg, and later, after improvement in the pain had set in, it reappeared in the left leg. The patient had become an opium-eater. So far as I know, this instance of the disappearance of the knee-jerk in sciatica is unique, and it is impossible to determine whether it stands in any causal relation to the neuralgia.

It has been stated by Eulenburg that the faradic irritability of the nerve is often diminished, and that the galvanic irritability also undergoes changes which may even amount to a reversal of the normal formula of contraction. Legros and Onimus state that they have observed increased faradic contractility in recent sciatica, and diminished contractility in old sciatica. Changes of such a character do not seem to have been seen by other writers, and it is very questionable whether they occur in true sciatica.

Various disturbances of cutaneous sensibility are often noticed. In the majority of severe cases tactile sensibility is blunted to a slight extent, but marked anæsthesia is rare. Hyperæsthesia is still rarer, and is usually con-

fined to circumscribed portions of the skin. Both forms of disturbed sensibility may be present at the same time.

The patients often complain of abnormal sensations in the skin, such as a feeling of cold, more rarely of heat, formication, tingling, etc. These sensations are often present, although tactile sensation is not affected.

The appearance of the integument is often changed. The skin may be pale and anæmic; it is frequently colder to the touch than the opposite limb; perspiration is usually diminished, though it is sometimes increased. These disturbances are probably the result of vaso-motor changes in the affected limb.

Trophic changes are rare. Apart from the muscular atrophy, to which reference has already been made, they include increased growth of hair in the area of distribution of the affected nerve, and rarely certain cutaneous eruptions, such as herpes, erythema, and furuncles. In very exceptional instances hypertrophy of the muscles of the thigh and calf has been observed. These trophic changes play a much less important part in the history of sciatica than they do in that of other neuralgias.

The paroxysms of pain come on at irregular intervals, and rarely present the periodicity which is so often a striking feature of other neuralgias, even when they are non-malarial in origin. They may be brought about by numerous exciting causes, such as the movements of coughing, straining at stool, turning in bed, etc. If the disease lasts for any length of time, the paroxysms are apt to occur with greater frequency but less severity, until finally the patient suffers constantly from pain and the disease enters the chronic stage.

Diagnosis.—The diagnosis in typical cases is usually very easy. The situation and character of the pain, its occurrence in paroxysms, the presence of painful points, the slight disturbance, as a rule, of motion and sensation —all show clearly the nature of the disease. Lazarevic mentions as a pathognomonic sign that there is increased pain and tenderness on extending the knee and ankle and flexing the thigh on the abdomen. He believes that this is owing to the elongation of the nerve produced by this manipulation.

We should not remain satisfied with the mere diagnosis of sciatica, but should at the same time endeavor to discover the cause of the attack. In order to do this we must go into the previous history of the patient and the mode of development of the neuralgia, and, if this is unsuccessful, should carefully examine the adjacent organs along the course of the nerve, bearing in mind the various processes, mentioned in the section on etiology, which may give rise to the disease. As in all other forms of neuralgia, however, we shall meet with not a few cases in which it is impossible to ascertain the cause.

Easy as the diagnosis is in many cases, in others it is extremely difficult. Perhaps no condition offers greater difficulties in this respect than rheumatoid arthritis of the hip-joint. Jonathan Hutchinson even goes so far as to claim that nine-tenths of the so-called chronic cases of sciatica are really cases of rheumatoid arthritis. Although I admit that the differential diagnosis may be very difficult, and a number of cases of errors in diagnosis have come under my own observation, I am convinced that Hutchinson's statement is greatly exaggerated. In rheumatoid arthritis the pain is usually by no means so severe as in sciatica, and it is not confined so exclusively to the distribution of the sciatic nerve. Equally severe pain is felt along the crural, and especially the genito-crural, nerve. On making passive motion at the hip-joint, it will be found that flexion is limited in amount, and, after the limb is bent on the abdomen to a certain extent, further flexion is impossible without tilting the pelvis. Rotation at the hip-joint is also interfered with. In some cases rough creaking can be felt in the joint. The ankylosis in these cases may be either true or false.

In rare cases sciatica may be mistaken for hysterical hip-disease (Brodie's joint). In the latter disease there is remarkable tenderness on the slightest pressure of all the parts surrounding the joint, but uniform, strong compression often feels grateful to the patient. The pain is more diffuse than in sciatica, and the patient is generally a young woman who presents other manifest evidences of hysteria. Brodie's joint is, moreover, much more apt to be mistaken for true morbus coxæ than for sciatica.

When the sciatica is bilateral, it must be differentiated from locomotor ataxia. The very fact that the disease is bilateral should arouse our suspicions. But the pains of ataxia possess more of a fulgurating character than those of sciatica, are more irregular in their distribution and mode of onset, and are generally accompanied by more marked sensory disturbances. With very rare exceptions, the patellar tendon reflex is absent in ataxia, but too much reliance should not be placed on this sign, inasmuch as there are not a few healthy individuals in whom this reflex is absent. In addition, the pains of ataxia are usually accompanied by some of the other symptoms of ataxia (the characteristic gait, bladder disturbances, cincture feeling, Argyll-Robertson pupil, etc.).

Myalgia, or "rheumatism" of the muscles of the buttock and thigh, must also be excluded. The pain is sometimes of a darting character, but does not shoot along any particular nerve. The characteristic puncta dolorosa of sciatica are not present. The patient has, perhaps, often suffered from myalgia in other parts of the body. The pain is absent when the patient lies down and keeps the parts perfectly quiet. Moreover, this condition usually is much more amenable to treatment than sciatica.

Prognosis.—Recovery from sciatica sometimes takes place in a few days, but, as a rule, several weeks at least elapse before the pain disappears completely. The disease also exhibits a very decided tendency to relapse. For months, and sometimes even for years, after an attack of ordinary severity, the patient is liable to have an occasional twinge of pain in the limb after any unusual exertion, exposure, or slight injury. In not a few cases the relapses occur at gradually shorter intervals of time, and the disease finally becomes chronic. In rarer cases the first attack continues for an indefinite period. This is particularly true of those cases in which the disease begins at an advanced period of life, or in which the patients exhibit the signs of early senility. But the obstinacy of the affection does not always appear to depend upon impairment of the general condition. It is often extremely severe and intractable to treatment in robust individuals, who are otherwise apparently in perfect health.

Treatment.—As in all other diseases which exhibit a tendency to run an obstinate or even chronic course, the number of remedies employed in sciatica is legion.

Our first object should be to ascertain the cause of the attack and to combat the primary disease by appropriate measures (antisyphilitic, antirheumatic, antimalarial remedies, etc.). But in the majority of cases we must adopt a purely empirical treatment. It is well to begin by administering a cathartic and by securing sufficient daily evacuations from the bowels.

In my experience electricity, strychnine, and baths have been the most effective curative agents.

Of the various kinds of electricity I now employ only galvanism. It is usually applied as the stabile descending current, or by the polar method. In the former method the anode is placed upon the sacrum or lower lumbar vertebræ, the cathode to the puncta dolorosa; or if none is present, to the most accessible portions of the nerve (sciatic foramen, between the trochanter and ischium, along the thigh, or in the popliteal space). Or the anode, instead of being kept on the sacrum throughout the entire sitting, is shifted to the part first occupied by the cathode at the end of three or four minutes, the cathode being moved to the next lower point, and the whole length of the nerve is then traversed in this way. I have not noticed any difference in the results, however, whether the cathode was applied above or below. In the polar method the cathode is applied to the middle of the back or front of either thigh, the anode successively to the parts mentioned above. The sponges should not be too large, and the current must be of sufficient strength to cause severe pain. In fact I have found, as a rule,

that the stronger the current is, the more marked and lasting is the effect. At the end of the sitting the current may be interrupted a few times in order to produce muscular contractions. This is often very effective in diminishing the stiffness of the limb. The sittings should last about ten minutes, and be held daily, or every other day.

The faradic current has also been used, either with the wire brush applied to the painful points, or as a strong current through the entire course of the nerve. In several cases, however, we have seen the pain aggravated by this current, and have now abandoned its use.

Electrical applications often produce prompt and marked relief. The pains subside very rapidly, the freedom of motion is very much increased, and in favorable cases a permanent cure is effected after a few sittings. In very few cases have I failed to obtain at least some temporary improvement.

Strychnine should be given in initial doses of $\frac{1}{48}$ grain three times a day, the dose being increased rapidly to the point of tolerance by the patient. This drug often produces gratifying results if given in sufficiently large amounts, but it is by no means as efficacious as galvanism. It may, or may not, be combined with the use of electricity.

I have always employed baths in the form of hot sitz-baths, and always as an adjuvant to other methods of treatment. The water should be as hot as the patient can bear, and the baths should last for five or six minutes. They may be repeated once or even twice a day, and are often followed by a certain amount of relief. If taken at bedtime they may enable the patient to obtain refreshing sleep.

Local irritation is also a valuable adjuvant in some cases. It may be produced by blisters, or by the actual cautery. Some writers even recommend the production of a blister by the application of a sufficiently strong current of galvanism, but this causes an unnecessary amount of pain. It is sometimes advisable to apply the blisters in successively lower positions, until the entire upper part of the nerve has been treated in this way. The actual cautery is to be applied lightly over the course of the nerve, since the production of an eschar is not necessary to the relief of the pain.

Among other non-medicinal agents massage has also been employed. Schneller has recently reported fifteen cases treated in this way with successful results. The average period required to effect a cure was two and a half weeks. Huenfault reports the cure in two weeks, by massage, of a case which had resisted all other methods of treatment.

Favorable results have also been reported from congelation of the entire limb by means of chloride of methyl.

Hypodermic injections of various substances, such as cold water, ether, nitrate of silver, cocaine, osmic acid (ʒ ss.–j. of a one per cent. solution) into the nerve have also been used, but the results are not very gratifying. It should be remembered that abscesses occur not infrequently from this method of treatment.

Numerous drugs are employed occasionally in obstinate cases, viz., morphine, arsenic, quinine, iodide of potassium, aconitine, atropine, gelsemium, and turpentine.

When the pain is intolerable we are often compelled to give a hypodermic injection of morphine in order to secure temporary relief. In rare cases a single injection is followed by marked permanent benefit. But this remedy should be used as sparingly as possible, inasmuch as we are unable to determine in advance the duration of the disease, and the patient may fall into the opium habit in consequence of its protracted administration. A case of this kind is now under my observation.

Aconitine sometimes produces excellent results, but its effects are far inferior in sciatica to the brilliant results so often obtained in trigeminal neuralgia. Arsenic will often be found a useful remedy in this disease, especially in the chronic cases occurring in old people. The same remark may also be made of iodide of potassium. I have seen very little benefit from the other remedies mentioned above.

Finally, surgical interference may be resorted to. Fayrer reports a case of aggravated sciatica of long standing, in which there were fulness and tenderness in the course of the nerve near its origin, in the upper part of the limb, together with a sense of fluctuation. A long, narrow knife was introduced into the swelling, until it entered the sheath of the nerve. This gave exit to a couple of drachms of clear serous fluid, and was followed by immediate relief. Fayrer states that he has seen other cases of a similar, but not so well-marked, character.

Nerve-stretching has also been employed in a large number of cases, but the results have not been as good as the first reports led us to expect. The stretching may be performed subcutaneously, by flexing the thigh forcibly on the trunk, while the knee is kept fully extended. Woelfler reports one brilliant result from this plan, but in thirteen other cases it proved an entire failure.

Stretching of the nerve after its exposure by incision has also been successful in a number of obstinate cases, and as the operation is unattended with danger it is always worthy of trial in desperate cases.

Leopold Putzel.

SCLERA, CORNEA, CRYSTALLINE LENS, VITREOUS BODY, ZONULE OF ZINN, AQUEOUS HUMOR. The sclera (sclerotic) and cornea form the outer, so-called hard, membranes of the eyeball which determine its shape. While the former is translucent only, the latter is transparent, with a refracting index which is almost equal to that of water.

Both the *sclera* and the cornea in the ideal eyeball form portions of a sphere. Generally, however, their curvature is only approximately spherical. Five-sixths of the globe are formed by the sclera, the anterior sixth by the cornea, which is inserted like a watch-glass upon the sclera, and has a smaller radius of curvature (see Fig. 3397). The depression which is formed in the sphere by this mode of insertion of the cornea upon the sclera is called the *sulcus scleræ*. The diameters of the eyeball are not equal in all directions. The antero-posterior diameter, the longest, averages 24 mm., while the vertical one is only about 23 mm., the horizontal diameter being between these two, or about 23.5 mm. The posterior portion of the sclera around the optic-nerve entrance is about 1 mm. thick; from this point it gradually tapers off toward the insertion of the cornea, near which its thickness is reduced to 0.5 or 0.4 mm.

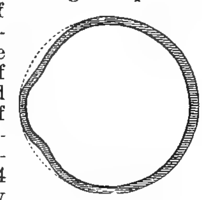


FIG. 3397.—Outline of the Sclera and Cornea.

The increased thickness in the posterior portion is mainly due to the fact that the sheaths of the optic nerve here enter the tissue of the sclera and coalesce with it. Close behind the insertion of the cornea the sclerotic tissue is also increased in quantity by the insertions of the tendons of the external ocular muscles.

At the sulcus scleræ the translucent tissue of the sclera passes over into the transparent tissue of the *cornea*. This is done in such a manner that the inner layers become sooner transparent than the outer ones. This part is called the *limbus corneæ* (sclero-corneal junction). The translucent tissue reaches farther over the transparent tissue at the upper and lower margins of the cornea than at the inner and outer ones, and thus the outline of the anterior corneal surface is that of an ellipse, while that of the posterior surface is circular. The diameters of the anterior corneal outline are 11.6 and 11.0 mm., respectively. The curvature of the cornea has also been said to be elliptical, causing, so to speak, a normal astigmatism (Donders, Knapp, and others). However, more recently, Aubert has come to somewhat different conclusions with regard to the curvature of the cornea, which he expresses in the following words: "We can distinguish between two zones in the cornea, of which one, the marginal zone, remains curved in accordance with the anatomical shape of the eyeball, while the other, the polar zone, serves the optical requirements. The shape of the

eyeball is such that the part defined by the sclerotic is almost spherical, with a radius of from 11 to 12 mm. The margin of the cornea has almost the same curvature as the sclerotic, of which it is a direct continuation. This portion then passes gradually over into a part of the cornea of a stronger curvature—a zone of the cornea which is immaterial for optical purposes, since the rays which fall upon it are kept from entering the interior of the eyeball by the iris. It is only where this sclerotic curvature of the eyeball is totally changed that the part of the cornea begins which is material for vision, and which forms an area of from twelve to sixteen degrees around the optical axis. The curvature of this part is such as to refract the rays of light falling upon it in a manner to unite them upon the retina. We may, therefore, speak of two zones (of curvature) in the cornea, of which the one, the polar, is the *optical zone*, while the other, the marginal, may be called its *scleral zone*. Their limits are given by the iris and pupil."

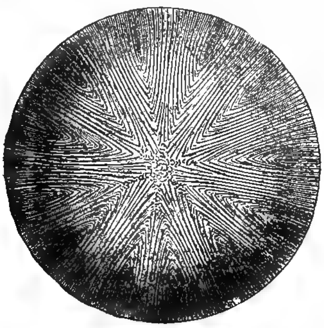


Fig. 3398.—Adult Lens, Anterior Surface. (Arnold.)

The cornea is thicker at its periphery than in its central portion, the thicknesses being 1.1 mm. and 0.9 mm., respectively.

Close to the inner surface of the sclerotic (*cf.* art. Iris) lies the uveal tract, and upon this (*cf.* art. Optic Nerve and Retina) is the expansion of the optic nerve, the retina. The fibres of the optic nerve enter the posterior pole of the sclerotic, somewhat to the nasal side, by numerous openings, which give this portion of the sclerotic the appearance of a sieve. From this it has been called the *lamina cribrosa* of the sclera. On its outer surface the sclera is surrounded by *Tenon's capsule*, from which it is separated by *Tenon's space*, a lymph-space.

The large cavity surrounded by the sclera (and choroid and retina) is filled with the *vitreous body*, a transparent, gelatinous substance. The general shape of the vitreous body is spherical. Its anterior surface, however, which lies at the level of the ciliary processes, has a central depression (*fossa patellaris*) in which lies the crystalline lens. Its posterior surface is also slightly changed from the spherical, by reason of its filling the physiological excavation of the optic papilla.

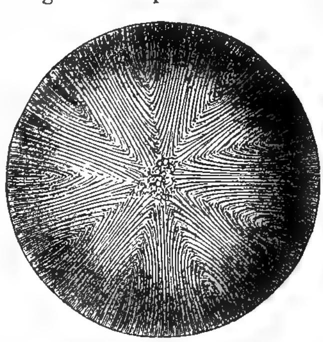


Fig. 3399.—Adult Lens, Posterior Surface. (Arnold.)

In front of the vitreous body lies the *crystalline lens*, with its suspensory ligament (*zonule of Zinn*). The crystalline lens is a perfectly transparent, lens-shaped body. It lies posteriorly in the fossa patellaris of the vitreous body; anteriorly it touches the pupillary edge of the iris. It is biconvex, and its equator lies at the level of the highest prominence of the ciliary processes. The curvature of its surfaces is unequal, the posterior surface having a stronger curvature than the anterior one. The equatorial diameter of the lens is from 9 to 10 mm., while the antero-posterior diameter is on an average 3.7 mm. It consists of a transparent capsule and the lens-substance proper. On both surfaces of the lens star-like figures may be seen, as are represented in Figs. 3398, 3399, and 3400. In the new-born we find three radii which, starting from the *anterior* and *posterior* poles, form angles of about 120°. While, on the anterior surface, one of these radii goes upward, and the remaining two downward and to the sides, these directions are reversed on the posterior surface. These radii never seem to reach the equator. In the adult the radii branch off, and their number is considerably increased. These radii have been called the sutures of the lens. (See Figs. 3398, 3399, and 3400.)

Fig. 3400.—Lens of the Newly-born, seen from the Side. (Arnold.)

The curvature changes with age, the lens being more convex in childhood and becoming gradually flatter. Its colorless structure also gradually takes on a yellowish amber tint with age. Its consistency is much firmer than that of the vitreous body.

The lens is held in its position by fibres which come from the ciliary processes, and attach themselves on the anterior and posterior surfaces of the capsule of the lens, close to its equator. These fibres together form the *suspensory ligament* (*zonule of Zinn, zonula ciliaris*). They come from the vitreous body (Arnold), and after having closely followed all the windings of the inner surface of the ciliary processes, they are bent almost at right angles toward the axis of the eyeball, and then attach themselves to the capsule of the crystalline lens. It was formerly thought that a triangular space could be demonstrated between those fibres that go to the posterior, and those that go to the anterior, lens-capsule, and this was given the name of *canal of Petit*.

The anterior chamber (the space which is bounded by the cornea, anterior surface of the iris, and as much of the anterior surface of the lens as lies in the pupillary space), and also the posterior chamber (the prismatic space bounded by the posterior surface of the iris, the zonule of Zinn, and the remaining portion of the anterior surface of the lens), are filled with a fluid called the *aqueous humor*. This water-like fluid closely resembles serum, but contains but little albumen.

Microscopical Anatomy.—*Cornea.*—The cornea consists of the anterior epithelium, *Bowman's membrane* (*Reichert's membrane, membrana elastica anterior*), the parenchyma or the corneal tissue proper, *Descemet's membrane* (*membrana Duddeliana, Demoursii, humoris aquei, lamina elastica posterior*), and the endothelium (*posterior epithelial layer*). (See Fig. 3401.)

The epithelium of the cornea is made up of a large number of layers like that of the skin, with the difference, however, that the cells of even the most superficial layer are never changed into horny scales, but have a nucleus like the cells of mucous membranes. (See Fig. 3401.) The innermost layer of the epithelium is, as a rule, a single layer, and consists of long cylindrical or club-shaped cells with an oval nucleus. Although these are in a general way the types of shape of these cells, they show all sorts of varieties in shape, into which they mould each other during their growth. It is not rare to find cells of two nuclei among them, which fact has led Waldeyer to the opinion that from this basal layer all other layers are derived.

Outward from the basal layer are several layers of cells which are more broad than they are high, and are polymorphous. These are characterized by two or more offsets, by which they are inserted in the interstices between the cells of the underlying layer. Their nucleus is rather spherical, and their shape depends on the pressure they exert on each other. Outward from these layers there follow two or three layers of serrated cells, that is, cells which have in all directions minute prick-like offsets by which they anastomose with each other. The most superficial portion of the epithelium consists of a number of layers of cells, becoming gradually more and more flattened, and having a flat nucleus, around which

the cells are slightly thickened. (See Fig. 3403.) Viewed from the surface these cells constitute a delicate mosaic.

All of these cells and layers are firmly bound together by a small amount of cementing substance.

The parenchyma of the cornea, that is, the corneal tissue proper (substantia propria), consists of the stroma, in which are embedded a system of canals (*corneal canals*) with cellular elements, a large number of nerves, and at its periphery a wreath of blood-vessels.

The stroma consists of very fine connective-tissue fibrillæ, which are somewhat wavy and intersect each other at varying angles. A cementing substance unites them with each other, and into fasciculi. Several fasciculi together are by the same cementing substance united into lamellæ, which, in turn, are bound together more or less parallel to the surfaces of the cornea. These lamellæ are thinner and more closely packed in the anterior portions of the cornea than they are near its posterior surface.

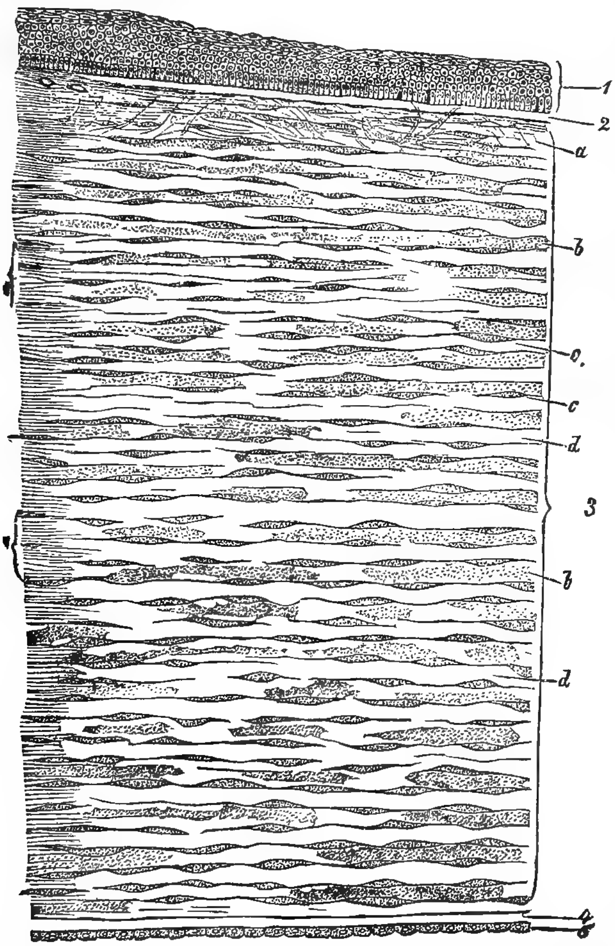


FIG. 3401.—Section through Human Cornea. (Waldeyer.) 1, Epithelium; 2, Reichert's or Bowman's membrane; 3, parenchyma of the cornea; 4, Descemet's membrane; 5, endothelial layer. *a*, Anterior layers of the substance proper of the cornea, fibres going to Bowman's layer. The canals are closer to each other. *b*, Points which represent transversely cut fibres and fasciculi; *c*, corneal corpuscles, appearing fusiform in section; *d*, fasciculi cut lengthwise, and therefore appearing homogeneous; *e*, *e*, sclero-corneal junction.

Between these fibrillæ, fasciculi, and lamellæ of the stroma of the cornea, and within the substance which cements them together as a whole, we find a system of canals which have received the name of *Von Recklinghausen's corneal canals*. (See Fig. 3404.) These canals, differing in width, intersect and communicate with each other at different angles. Here and there they have an enlargement which is called a lacuna. These lacunæ are especially found in the interlamellar canals, where they are seen to lie in rows parallel with the lamellæ. They are flattened in an antero-posterior direction, and therefore, in sections, they appear spindle-shaped. In a plane view they vary extremely in shape, according to the number of canals which are connected with each of them. As the lamellæ of the corneal stroma differ in thickness, so the canals and lacunæ differ in calibre in such a way that the canals and lacunæ are smaller and narrower in the anterior portions of the cornea than in the posterior ones. These canals and lacunæ are easily demonstrated by staining the corneal stroma by means of nitrate of silver or chloride of gold, or by injecting some colored fluid into them. (See Fig. 3404.)

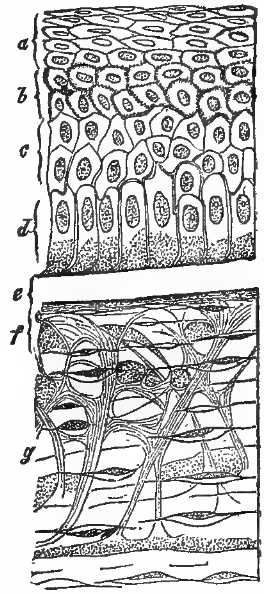


FIG. 3402. — Meridional Section through the Cornea of the Calf, (Waldeyer.) *a*, Flattened epithelial cells; *b*, prickle cells; *c*, polymorphous cells; *d*, basal layer of club-shaped cells; *e*, Bowman's layer; *f* and *g*, substantia propria of the cornea.

Within the lacunæ (see Fig. 3405) lie the so-called fixed corneal cells (*corneal corpuscles*). When isolated they are found to be flat protoplasmic bodies, with a round or oval nucleus and several offsets. These cells never wholly fill the lacuna in which they lie. Usually they are seen to adhere to one wall of it, and to fill about two-thirds of its cavity. Their offsets can generally be traced for a short distance within the canals which communicate with their lacunæ. Although called fixed cells, they are not so in the full sense of the word, and they have been observed to change their position within the lacuna. Near the sclero-corneal juncture, and especially in the eye of the negro, these cells contain sometimes a granular brown pigment which is enclosed within their protoplasm, leaving the nucleus free.

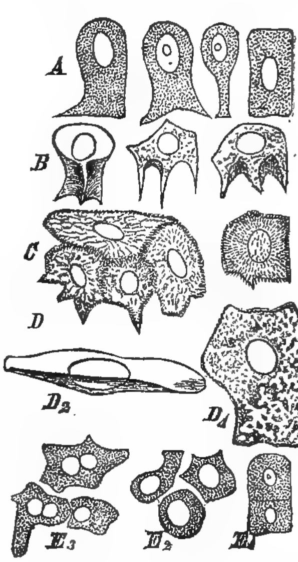


FIG. 3403.—Isolated Cells of the Corneal Epithelium. (Waldeyer.) *A*, from the basal layer; *B*, polymorphous cells; *C*, prickle-cells; *D*, flattened cells; D_1, plane view; D_2, side view; E_1, E_2, E_3, young cells from the middle layers; E_1, cell undergoing division; E_2, cells with one nucleus; E_3, cells with several nuclei.

While some authors (Kuehne and others) hold the opinion that the corneal canals and lacunæ are filled with protoplasm, thus forming a solid network within the connective tissue of the cornea, the large majority of authors consider them to be lymphatic canals.

In these canals we find, further, a limited number of

lymph-cells (wandering cells), which differ, of course, in nothing from the lymph-cells found in other tissues.

Another system of canals which is in communication with the lymph-canal system, but which lies almost at right angles to the latter, consists of the canals in which the nerves of the cornea are situated.

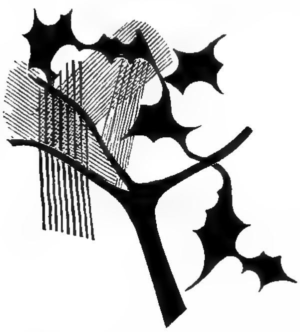


FIG. 3404.—Interfibrillar and Interlamellar Canals, and one Nerve-canal Injected. They all communicate with each other. The lines of the interfibrillar canals are wrongly drawn as straight lines in the cut. They are in reality wavy.

The anterior surface of the parenchyma of the cornea is formed by a layer which, varying in thickness in different eyes, with a moderate magnifying power appears structureless, and very much resembles a vitreous membrane. This is called *Bowman's*, or *Reichert's, layer*. (See Fig. 3398.) With a higher magnifying power this membrane is seen to be striated, and therefore to consist also of different layers, and to be, in fact, only condensed corneal tissue. Fibres are seen to go to it from the adjacent layers of the corneal parenchyma, and to join it at varying angles. With the proper agents it can be split into layers, and even fibrillæ. Close upon its outer surface lies the corneal epithelium, and some authors have described ridges on it into which the epithelial cells are said to fit.

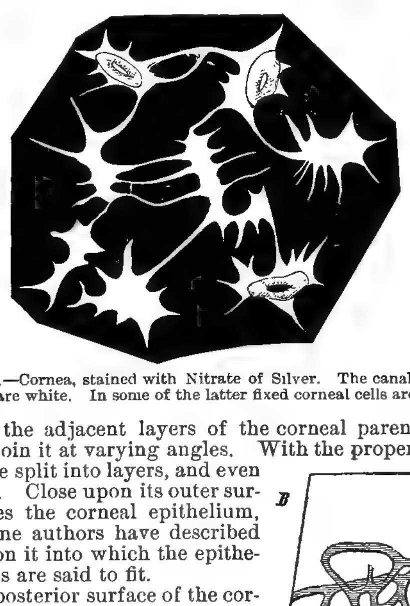


FIG. 3405.—Cornea, stained with Nitrate of Silver. The canals and lacunæ are white. In some of the latter fixed corneal cells are seen.

The posterior surface of the corneal parenchyma is bound by a thinner, double-contoured, elastic vitreous membrane, which seems to have more claims to be regarded as an independent membrane. This is commonly called *Descemet's membrane*. (See Fig. 3398.) Some authors consider this membrane also to be only a condensation of the corneal tissue. It can, however—and this often happens in pathological conditions—be perfectly detached from the parenchyma. This is not the case with Bowman's layer. The fact that it is an elastic membrane, and rolls itself up when freed from its adhesion to the corneal parenchyma, seems no longer to be doubted.

On its inner surface Descemet's membrane carries one layer of epithelial (endothelial) cells. (See Fig. 3406.) These cells vary considerably in height in different eyes, and in shape in one and the same eye. In sections they appear cuboid, in surface views they are hexagonal, rhomboid, or square, or, in general, have a shape which is dependent on the pressure which the different cells exert upon each other during their growth. They have generally a round nucleus, and are held together by a small amount of cementing substance.

Between these endothelial cells we find very frequently, perhaps oftener in old eyes than in young ones, a varying number of roundish transparent bodies which sometimes coalesce with each other. (See Fig. 3409.) They are usually situated near the periphery of Descemet's membrane, very much resemble the colloid excrescences on the lamina vitrea of the choroid, and crowd the surrounding endothelial cells aside. They are usually called *vitreous warts* of Descemet's membrane (Hassal).

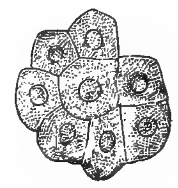


FIG. 3406.—Endothelial Cells of Descemet's Membrane. (Waldeyer.)

The corneal parenchyma does not contain any blood-vessels, except in a portion of from one to three mm. in width at the corneo-scleral junction. The arteries going to this wreath of blood-vessels come from the anterior ciliary arteries, either directly, or indirectly by way of the conjunctival arteries. They are found in loops, which unite to form a narrow network of capillaries. The veins are of a rather large calibre. (See Fig. 3407.) Several authors have described two separate wreaths of blood-vessels, one of which is said to lie closer to the anterior, the other closer to the posterior, surface of the cornea. The loops formed by the capillaries often show a number of teat-like projections toward the centre of the cornea.

At its periphery the cornea is entered by from forty to forty-eight larger nerve branches which come from the anterior ciliary nerves of the sclerotic and conjunctiva. After having entered the cornea these nerves very soon lose their double contour, branch off dichotomously, and thus form a network within the stroma of the cornea. (See Fig. 3408.) From this network branches go forward at different angles toward Bowman's layer, and near it form another network. At this part the axes-fibrillæ and axes-cylinders pierce Bowman's layer almost at right angles, form one network around the basal cells, and another between the more superficial layers, from which fine branches can be traced into the most superficial layer. Whether they end in these cells or protrude on the surface and form special nervous corpuscles there (Cohnheim), is, as yet, an unsettled question.

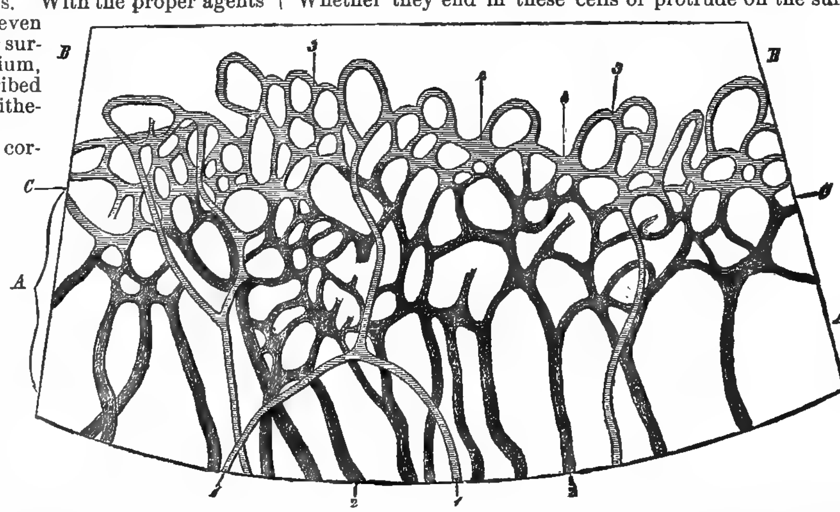


FIG. 3407.—The Loops of Blood-vessels found in the Periphery of the Cornea. *A*, Region of the bulbar conjunctiva; *B*, region of the cornea; *C*, line of junction between cornea and sclera. 1, Arteries; 2, veins; 3, marginal loops; 4, lacuna-like enlargements where several loops join each other and the veins. (Waldeyer.)

As has been already stated, the nerves lie in canals, which communicate with the lymphatic canals of von Recklinghausen and can be injected. These nerve-canals seem to have a layer of endothelial cells.

At the *corneo-scleral junction* the corneal epithelium goes directly over into the conjunctival epithelium.

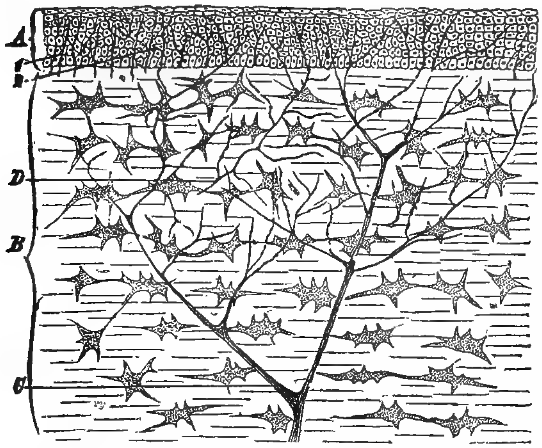


FIG. 3408.—Oblique Section through Human Cornea stained with Chloride of Gold. (Waldeyer.) *A*, epithelium with intra-epithelial nerve-plexus; *B*, substantia propria of the cornea; *C*, nerve branching off dichotomously; *D*, axes-cylinders; 1 and 2, anastomosing axes-fibrillæ.

Bowman's layer and the anterior layers of the corneal parenchyma pass over into the conjunctival tissue, and the bulk of the parenchyma of the cornea becomes scleral tissue. The membrane of Descemet and the adjacent layers form a network of fibres which lies on the inner surface of the tendon of the ciliary muscle, and is called *ligamentum pectinatum* (*pectineum*). (See Fig. 3409.) In accordance with this arrangement, the anterior portion of the cornea has been called the conjunctival, the middle the scleral, and the posterior the choroidal, portion of the cornea.

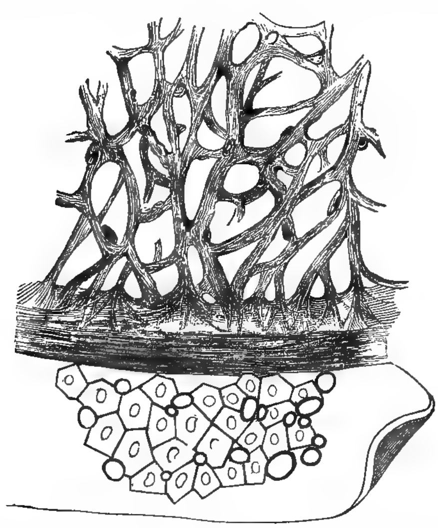


FIG. 3409.—A Portion of Descemet's Membrane and the Ligamentum Pectinatum. On Descemet's membrane may be seen some endothelial cells, and between them a number of glassy warts.

The fibres of the ligamentum pectinatum, when detached, appear as tough vitreous fibres to which a number of endothelial cells adhere. These fibres form a network, the meshes of which (*Fontana's spaces*) are in communication with a system of lymphatic spaces which lie between the inner fibres of the corneo-scleral junction and go to Schlemm's canal.

The fibres of the ligamentum pectinatum are lost in the tissue of the ciliary body and iris.

The tissue of the *sclera*, like that of the cornea, consists of very fine connective-tissue fibrillæ, which are, however, not quite so transparent, and differ from the corneal fibrillæ in their chemical character. It contains, moreover, some elastic fibres. The scleral fibrillæ, like those of the cornea, are bound together by a cementing substance, and thus form fasciculi. The scleral fasciculi are not arranged in more or less parallel lamellæ, but are interwoven at different angles. In a general way, the fasciculi in the sclera run in a meridional (longitudinal) direction. An equatorial (circular) arrangement of the fasciculi, however, is found constantly around the optic-nerve entrance and near the corneo-scleral junction, behind the ligamentum pectinatum.

Between the fasciculi of the sclera, and within the cementing substance, we find a network of lymphatic canals similar to those of the cornea. Their arrangement is, however, very irregular, and resembles more the arrangement found, for instance, in the tissue of larger tendons. This system of lymphatic canals is readily demonstrated by staining with nitrate of silver or chloride of gold, or by injection. We find then that the scleral system of canals has also lacunæ, like the corneal ones, and embedded in these lacunæ are stellated cells, the analogue of the fixed corneal cells. They resemble the latter in shape, are protoplasmic bodies with a number of offsets and a round or oval nucleus. Near the corneo-scleral junction, and around the optic-nerve entrance, these cells are often found to contain a granular brownish pigment. This is especially the case in negroes' eyes. A small number of lymphatic (wandering) cells are also found in the canals of the sclerotic.

At the optic-nerve entrance (see article Optic Nerve and Retina) the sheaths of the optic nerve merge into the tissue of the sclerotic, the dura-mater sheath joining the outer layers, the pia mater mingling with the inner layers of this membrane. The intervaginal space reaches into the sclera to a varying depth, sometimes splitting this membrane for a short distance into two portions. The fibres of the sheaths of the optic nerve make a part of the equatorial (circular) fibres of the sclera found around the optic-nerve entrance.

The tendons of the six extra-ocular muscles are inserted upon the sclera at very acute angles. Their fibres are seen to enter the scleral tissue, and may be traced for some distance, when they are gradually lost. According to Loewig, the fibres of the tendons of the recti muscles form longitudinal (meridional) fibres in the sclera, while the fibres of the oblique muscles form circular (equatorial) fibres.

As we stated above, the optic nerve is not admitted into the eyeball by one large round opening in the sclera, but in such a manner that its bundles enter the eyeball separated from each other by a sieve-like network of fasciculi of the sclera (*lamina cribrosa*).

The outer and inner surfaces of the sclera are covered with a layer of flat endothelial cells, of a more or less rhomboid shape. These cells can be easily demonstrated by staining with nitrate of silver. On the inner surface of the sclera the endothelial lining is pierced by numerous fibres, which unite the choroid with the sclera and form the *lamina fusca*.

This name has been given to the network of fibres, intermingled with pigmented stellate cells, which remain adherent to the sclera when the choroid is torn from it. On the outer surface of the sclera a similar condition obtains, the endothelial layer being pierced by many fibres, which form the loose episcleral tissue, and join the conjunctiva anteriorly and posteriorly to Tenon's capsule. Endothelial cells are also found adhering to these fibres.

The whole thickness of the sclera is pierced in a number of places by blood-vessels and nerves, which in this manner enter the eyeball and go to the uveal tract or come from it. These are the ciliary arteries and nerves,

and the venæ vorticosæ. Blood-vessels and nerves are surrounded by a lymphatic space with an endothelial membrane. The posterior ciliary arteries and nerves frequently lie together in one such sheath. By these sheaths the suprachoroidal lymph-space directly communicates with Tenon's space.

During their passage through the sclera both the anterior and posterior ciliary arteries give off branches for this membrane. The same is done by the nerves.

The anterior ciliary arteries enter the sclerotic with the tendons of the recti muscles.

At the corneo-scleral junction we find always a larger number of blood-vessels of an arterial character. Aside from these there is a venous plexus (Leber) which surrounds the periphery of the cornea, lying near the inner surface of the corneo-scleral junction. There is, furthermore, always a large canal to be found in this tissue just to the outer side of the insertion of the tendon of the ciliary muscle and the ligamentum pectinatum, which seems to be a lymphatic canal, and goes by the name of *Schlemm's canal*. In longitudinal sections it appears as an elongated opening with an endothelial lining. Its inner wall is perforated, and by means of Fontana's spaces and the lymph-fissures in the tendon of the ciliary muscle, Schlemm's canal seems to communicate with the anterior chamber. Leber contends that what by others is maintained to be a lymphatic canal, is the very venous plexus so well described by him. I am of the opinion that there is a venous plexus, and, aside from it, also a lymphatic canal, which latter corresponds to what has been called Schlemm's canal.

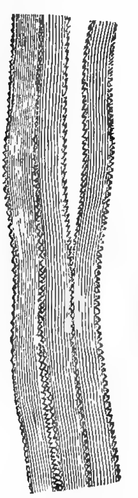


FIG. 3410.—Isolated Lens-fibres stained with Nitrate of Silver. (Arnold.)

The *crystalline lens* consists of the lens-capsule (anterior and posterior), the intra-capsular epithelium, and the lens-substance (lens-fibres, lens-bands).

The lens-capsule forms a hyaline sac, so to speak, in which the remainder of the constituents of the lens are inclosed. It is one continuous membrane. From the clinical distinction between an anterior and a posterior capsule, it might seem to follow that we have to deal with two different membranes, but this is not the case. There is, however, a distinct difference between that part of the capsule which covers the anterior surface of the lens and the portion which covers the posterior surface, in so far as the former is considerably thicker than the latter. The reduction in thickness takes place near the equator of the lens. This difference in thickness seems to be mainly due to the fact that a much larger number of the fibres of the zonule of Zinn (suspensory ligament) merge into the capsule in front of the equator of the lens than behind it.

The lens-capsule is an elastic hyaline membrane. In a plane view it appears homogeneous. Its transverse section, with a very high magnifying power and after the use of certain reagents, shows a fine striation. Its elastic nature is proven by the fact that it rolls up when severed from the lens-substance.

The inner surface of the anterior lens-capsule is lined by a single layer of epithelial cells. In a plane view they appear more or less hexagonal. In transverse sections their height is about that of the thickness of the lens-capsule; yet their size and shape vary in different eyes. They are held together by a small quantity of cement-substance. Their nucleus is round or oval. This epithelial layer does not reach beyond the equator of the lens, and near it we find that the cells become elongated, cylindrical, and gradually assume the form of lens-fibres. The view which is maintained by almost all investigators on this subject, that the continued formation of new lens-fibres takes place at the equator, has of late been declared absolutely incorrect by Robinski. The opinion advanced by him is that new cells are formed all over in the epithelial layer by karyokinesis, and that the process is therefore not confined to the equator.

The posterior capsule has no epithelial lining.

The lens-substance consists of the so-called lens-fibres (lens-bands, lens-tubes). Isolated lens-fibres appear as flat bodies with a very fine longitudinal striation (see Fig. 3410), and in rare cases also a transverse one. When they happen to lie on edge they appear much thinner. In transverse sections they are seen to be in reality hexagonal prisms (see Fig. 3411), which are smaller and thinner when taken from the nucleus of the lens than when taken from its periphery. While the younger and peripheral lens-fibres have an oval nucleus somewhere in their protoplasmatic body, the older and central lens-fibres have none for the most part.

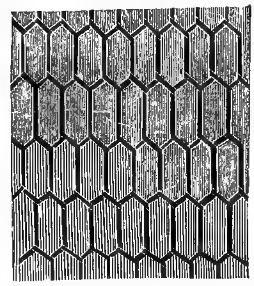


FIG. 3411.—Section through a Frozen Lens stained with Nitrate of Silver, showing Hexagonal Shape of Lens-fibres. (Arnold.)

The lens-fibres have also been called lens-tubes, since they evidently consist of a tough peripheral substance and a more fluid one within this. The latter is called *liquor Morgagni*. This fact is especially evident in the young lens-fibres near the periphery. As we come nearer to the centre of the lens, the Morgagnian fluid disappears gradually, and the fibres grow flatter and harder. The outlines of the fibres in the nucleus of the lens are rough and indented, and their lines of union with each other resemble bone-sutures. All the fibres are held together by a small quantity of cementing substance.

From the foregoing it will be seen that in the lens-substance we find layer upon layer of lens-fibres arranged in a more or less concentric manner. The peripheral fibres are the youngest ones, the central fibres are the oldest ones. The latter form the nucleus of the lens. The whole of the lens-tissue is epithelial in nature, and the old nuclear lens-fibres correspond to the oldest epidermic cells which have undergone a horny metamorphosis. In a meridional section through the poles of the lens, the nuclei of the lens-fibres are seen to be arranged in a convex line, with the convexity toward the capsular epithelium and near it. (See Fig. 3412.)

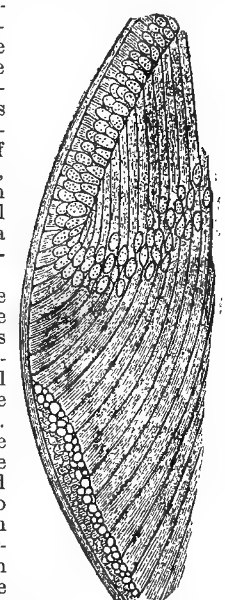


FIG. 3412.—Meridional Section through Lens of the Embryo of the Calf. (Arnold.) Shows the arrangement of the nuclei of the lens-fibres.

According to J. Arnold, the peripheral lens-fibres are from 0.010 to 0.012 mm. in breadth, and from 0.0045 to 0.0055 mm. in thickness; while the central ones are but 0.007 to 0.008 mm. in breadth, and from 0.0022 to 0.0021 mm. in thickness. Their length, according to Robinski, averages in the eye of the newly-born 5.5 mm., while in the eye of the adult it varies from 7.18 to 10.64 mm.

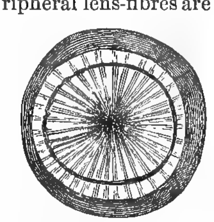


FIG. 3413.—Equatorial Section of the Human Vitreous Body, hardened in Mueller's Fluid. (Schwalbe.)

The *vitreous body*, which fills about the posterior two-thirds of the eyeball, consists of a more solid mucoid part and a thin fluid one, which runs off when the vitreous body is taken from the eyeball. The firmer portion amounts to 0.021 to 0.07

parts in 100 parts of vitreous body, according to Lohmeyer. This substance seems to form a number of very thin meridional and equatorial septa in which the fluid portion of the vitreous body (*vitrina ocularis*) is held confined. (See Fig. 3413.) It is very difficult to demonstrate these septa, yet their existence seems to be generally admitted. Concentric (equatorial) septa seem to be wanting in the more homogeneous central portion of the vitreous body, while they appear to be very numerous in its periphery. Probably for this reason the peripheral portion of the vitreous body is denser and firmer than are its central portions. From the lymphatic canals of the optic nerve a central canal in the vitreous body may be injected, which reaches from the optic papilla to the fossa patellaris. In this canal (*canalis hyaloideus*) during fœtal life the hyaloid blood-vessels go to the crystalline lens. After birth these blood-vessels

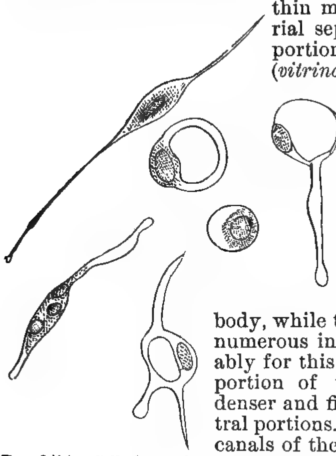


FIG. 3414.—Cells from the Vitreous Body.

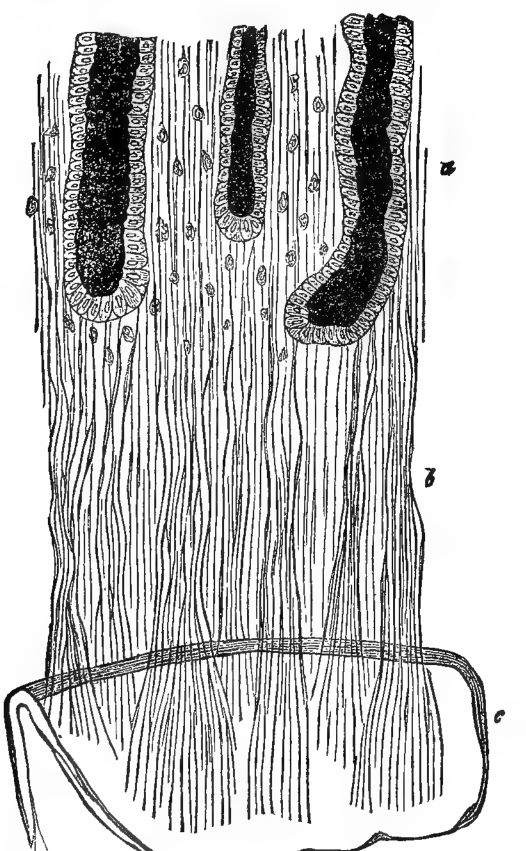


FIG. 3415.—Zonula Ciliaris (Suspensory Ligament of the Crystalline Lens). Plane View. The pigment of the ciliary processes remains lying on the pars non-plicata (*a*) of the zonule; the fibres of the pars plicata (*b*) go to the lens-capsule (*c*) and merge into it. (Arnold.)

no longer exist, excepting in a few cases in which persistent hyaloid blood-vessels may be found as an anomaly.

A number of authors have described a separate membrane, as *membrana hyaloidea*, which was said to cover the whole of the vitreous body, and thus to lie between it and the inner surface of the retina. Others contend that no such separate hyaloid membrane exists. The latter seems to be the correct opinion.

The vitreous body always contains a number of cellular elements, but their mass in the normal condition is but small in comparison to the bulk of the vitreous body. There are usually more cells to be found in its peripheral parts than in the central ones. The nature of all of these cells is that of lymph (wandering) cells, which enter the vitreous body from the surrounding membranes. (See Fig. 3414.)

With regard to their shape these cells (like all wandering cells) differ very greatly. There are simple round cells with one or more nuclei; there are round cells containing one or more vacuolæ, which sometimes crowd the nucleus aside so as to give the cell the appearance of a seal ring; there are, furthermore, cells with one or more offsets, some of which are very long.

Fibres, which by some investigators have been found in the vitreous body, seem to be pathological in nature.

The *suspensory ligament* of the crystalline lens (zonule of Zinn) springs from the vitreous body near the ora serrata of the retina. (See article Optic Nerve and Retina.) It lies at first close to the retinal (inmost) portion of the ciliary body, and has, therefore, here a pars non-plicata and a pars plicata just like the ciliary body. At the level of the ciliary processes the suspensory ligament is bent toward the axis of the eyeball, and is inserted into the lens close to its equator. This ligament consists of tough glassy fibres which sometimes show a fine transverse striation. They are held together in the manner of a membrane by a very small amount of a homogeneous cement-substance. From the ciliary processes these fibres are seen to go in the main to the anterior capsule of the lens, while a few go to the posterior capsule, and some return to the vitreous body. It was formerly thought that there was a triangular space bounded by the two portions of the suspensory ligament and the equator of the lens (canalis Petiti). Such a single large space does not actually exist, but the fibres crossing each other on their way in different directions leave a multitude of small spaces between them. At their point of insertion upon the lens-capsule the fibres of the suspensory ligament are lost in the tissue of the capsule. The cells which are sometimes found lying upon and between the fibres are lymph-cells.

Adolf Alt.

SCLERA, DISEASES OF THE. Although the sclera becomes secondarily involved in various morbid processes originating in other parts of the eyeball, primary disease of this structure is comparatively rare. Scleritis, or inflammation of the sclerotic, as a primary affection, is recognized only as originating in a narrow zone of the sclera, bounded in front by the cornea and behind by the insertion of the recti muscles. In this situation we meet with two varieties of scleritis—simple and complicated.

SIMPLE SCLERITIS (episcleritis) commences as a localized subconjunctival hyperæmia at a short distance from the corneal margin. As the episcleral tissue becomes infiltrated, a smooth swelling appears, which is but slightly elevated above the surrounding surface, and is usually of a dingy yellowish-red color, sometimes resembling a pustular formation, though ulceration or loss of substance never occurs. The conjunctival vessels over and around the swollen part are more or less engorged, but the conjunctiva in general remains normal. After a few days or weeks the nodule assumes a dull violet hue and becomes flatter, in which form it may remain stationary for a long time, or may gradually disappear, leaving a more or less permanent dull gray or ash-colored spot. Occasionally two or more such nodules are present at the same time, or as one disappears others may develop. The slow progress and tendency to recurrence of these nodules frequently render the disease tedious and protracted. One or both eyes may be affected, or as one recovers the other may undergo the same process.

The subjective symptoms are seldom severe; they con-

sist in an unpleasant sensation of weight or pressure in the eye, undue sensitiveness to light or cold, and perhaps slight headache; rarely there may be considerable photophobia and sharp pain. This disease belongs almost exclusively to adult life, and is most common in elderly people. The gouty, the rheumatic, and the scrofulous diatheses are all credited with lending a predisposition to this form of scleritis.

Treatment.—Any special dyscrasia on the part of the patient must be taken into account and suitably dealt with; and while exercise in the open air is to be enjoined, the eye must be protected from strong light and from sudden changes of temperature. The local use of sulphate of atropine is allowable in the early stages, especially if there be marked symptoms of irritation. In the absence of these, instillations of solution of eserine—gr. ij. ad ℥ j. (eserine, 0.10; water, 25.00)—twice daily, are often very efficacious. Massage, with the employment of oxide of mercury ointment (amorphous yellow oxide of mercury, 1 part, and fat or vaseline, 25–50 parts), has been highly recommended. Dry or moist heat, applied to the eye in the usual way, several times daily, may be beneficial.

In regard to internal medication the choice of remedies will depend on various circumstances. Mineral waters, iodide of potassium, salicylate of soda, proto-iodide of mercury, hypodermic injections of pilocarpine, and many other remedies have been used with more or less success, according to the special indications present in the individual case.

COMPLICATED SCLERITIS (sclero-keratitis, scrofulous scleratitis).—This is a much more serious affection, owing to the involvement of the cornea, iris, and ciliary region in the inflammatory process, and also to the tendency which exists to disastrous changes in any or all of these parts. Sclero-keratitis, commencing on the sclerotic, begins with one or more dusky infiltrations of the sclerotic, as in simple scleritis, but close to the corneal margin, the cornea being involved from the first, or after the scleral affection has existed only a short time; the pericorneal tissues are more deeply and more generally involved than in simple scleritis, and in some cases the cornea becomes extensively opaque; sooner or later the iris may participate in the inflammation, as is shown by visible changes in its appearance and by the presence of posterior synechia, or the entire ciliary region may become intensely congested and sensitive (irido-cyclitis). The special dangers to which the eye is subjected in any given case may be approximately estimated by the severity of the disease in the several parts affected—extensive changes in the cornea threatening permanent opacity of this structure; in the iris, more or less complete posterior synechia, and in the ciliary region, ciliary staphyloma. There may be one or more foci of inflammation; when there are several of these, the entire pericorneal zone may be involved, or the same thing may happen more slowly through repeated relapses, each time a different area of this zone being attacked. The low dusky swelling of the sclerotic, continuous with a patchy opacity of the adjacent cornea, is the characteristic objective sign of this disease, which, as a rule, is subacute in all its manifestations. Occasionally, however, the inflammatory process is more active, and there are intense photophobia, considerable lachrymation, and severe pain. The disease may at any time subside, leaving a dull grayish, thickened appearance of the sclerotic, and a corresponding irregular marginal opacity of the cornea. If several foci have been present, the cornea will have the appearance of being irregularly encroached upon by the sclerotic. With the subsidence of the inflammatory process the dull slaty-gray sclerotic may present a zone of thickened tissue around the cornea, which sometimes looks as if it were pushed forward, giving the anterior part of the eyeball an elongated appearance; or, more frequently, the sclerotic immediately around the cornea yields in certain places, and an irregular, nodular-looking projection is formed behind the cornea. This nodule is sharply defined anteriorly, but becomes gradually flattened toward the level of the normal sclerotic posteriorly. After repeated attacks of inflammation the staphylomatous bulging may involve the entire circumcorneal zone of the sclerotic, giving rise to great enlargement and distortion of the anterior part of the eyeball (Fig. 3416); at the same time the iris may become expanded from the periphery, and the anterior chamber is often considerably enlarged. The development of staphyloma from this cause does not often depend on increased intraocular tension, but on a gradual expansion of the softened sclerotic, and the most extensive changes in the form and appearance of the eyeball are not inconsistent with fairly good vision.

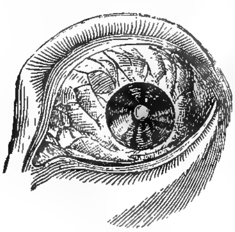


FIG. 3416.

The subjects of this disease are usually young adults, and it affects women far more frequently than men. "It is not known to be associated with any special dyscrasia, but it generally goes along with a feeble circulation and a liability to 'catch cold;' in some cases there is a definite family history of scrofula or phthisis" (Nettleship).

Treatment.—During the irritative stages soothing remedies are indicated. Protection from cold air and strong light is always advisable, warm fomentations are generally beneficial, and instillations of atropine are useful if there is much irritation, especially if the iris is at all involved.

In the more acute forms of this disease the writer has seen great improvement follow the use of antipyrine in doses of fifteen grains several times daily. Mercury may be used in moderation if the patient is not too anæmic. Iridectomy may be performed if there are extensive adhesions of the iris and a tendency to the development of staphyloma. If vision is destroyed and the eyeball is greatly enlarged, an operation for the removal of the staphyloma may be indicated.

Staphyloma of the sclera (ectasia) occurs under the most varied conditions, but usually as the result of prolonged increase of intraocular tension.

As a *congenital* anomaly of rare occurrence there is sometimes a partial bulging of the sclerotic, associated with congenital coloboma of the choroid (scleral protuberance of Von Ammon). There may also be a general uniform bulging of the sclerotic, associated with enlargement of the cornea, existing from the earliest infancy, and known as congenital "buphthalmus;" it commonly affects both eyes. Nothing is known of the etiology of this rare affection.

Extensive destruction of the cornea from suppurative keratitis is commonly followed by more or less complete corneal staphyloma, and this may extend to the sclera, giving rise to more or less general enlargement of the eyeball. Irido-cyclitis and irido-choroiditis, followed by occlusion of the pupil, give rise to increased tension of the eyeball, which, in the course of time, if not relieved, causes scleral staphyloma, usually in the ciliary region. Protracted increased tension from neglected glaucoma (glaucoma consummatum), or from dislocation of the lens, is a common cause of scleral staphyloma. Under these circumstances the bulging is usually far back, behind or between the insertion of the recti muscles.

In an ectasia following inflammatory or glaucomatous processes the protruding part is lined by a corresponding portion of the stretched and attenuated uveal tract. Bulging of the sclerotic may occur at any part, during the course of suppurative panophthalmitis, prior to rupture of this tunic and the escape of the contained pus.

Intraocular growths likewise cause bulging of the sclerotic, either by softening of the tunic in the vicinity of an intraocular growth, by the increased tension which such growths induce, or by simple expansion from excessive development of the growth. For the diagnosis of these conditions, see article Eye, Tumors of the.

Ectasia of the sclerotic at the posterior pole (sclero-ectasia posterior), as met with in axial myopia, is a condition of frequent occurrence. (See Myopia.) Its presence is easily determined, by means of the ophthalmoscope, by

the existence of a crescent or irregular circle of choroidal atrophy, which nearly always commences at the temporal side of the optic papilla. *F. Buller.*

SCLEREMA NEONATORUM. This rare affection is in no way connected with scleroderma, although the latter was at one time called sclerema of adults. It usually shows itself in the first days of extra-uterine life, having in all probability begun in fœtal life.

The first marked symptoms are commonly observed from the third to the sixth day after birth, when the lower extremities are seen to show considerable areas of shining, tense, white skin, sometimes tinged with red, or of a dirty-brown or yellowish color. The tissues are œdematous, pitting on pressure with the finger, while the skin is so much thickened that it cannot be pinched into folds between the thumb and fingers. Beginning in the calf, the disease soon extends to the thigh, spreads over the abdomen, up the trunk, involves the head and upper extremities, and, in fine, after a brief period (three hours to three days) invades the entire body. Of course we can know nothing of the subjective symptoms, but the rapid fall in body-temperature, the frigidity of the affected parts, and the general depression of functional activity point to a serious general condition.

The infant's bodily movements are imperfect and restrained; it lies numb and stiff, usually with closed eyes and wrapped in lethargic slumber; it declines food, partly on account of mental hebetude and partly because of the difficulty of making the movements of the mouth necessary to nursing. The heart is weak, and the pulse is rapid and sometimes almost imperceptible. The respirations are irregular and shallow, with occasional râles. The patient occasionally utters a complaining whine. The urine and stools are diminished in quantity.

The symptoms mentioned usually increase in severity with continually falling bodily temperature and increasing weakness, until death ends the scene at the end of from four to ten days.

Sclerema neonatorum is almost invariably fatal, though recovery has been noted in a few cases where the disease was not extensive. The cause of the disease seems to lie in an extensive implication of the blood-vessels. Atelectasis of the lungs, congenital disease of the heart, or other constitutional anomalies have been brought forward as explanatory of the origin of the disease. Surrounding and pre-natal conditions of an unfavorable hygienic character—want, privation, etc.—appear to have some influence in the causation of the disease.

Anatomical examination shows deep involvement of all strata of the cutaneous envelope. The widespread infiltration of the subcutaneous tissues allows the easy separation of these layers from the deeper layers of muscles and the fasciæ. On section a yellowish-white serous fluid, mostly composed of oil-globules, exudes. Of the internal organs, the lungs and kidneys are usually hyperæmic, while the brain and the serous membranes are usually œdematous. The brief duration of the affection, however, usually allows only the earlier stages of these changes to be observed.

The treatment of sclerema neonatorum is of a roborant and restorative nature, and should be undertaken at the earliest possible moment. Rubbing with hot blankets, etc., and the internal administration of restoratives may relieve the patient, and, if begun in time, may work a cure.

(The above article is based upon that of Schwimmer, "Ziemssen's Handbuch," Vierzehnter Bd., Erste Hälfte, S. 451.) *Arthur Van Harlingen.*

SCLERODERMA. An affection of the skin chiefly characterized by changes in the color and density of the integument, and in some cases accompanied by marked deformity.

Two varieties are usually described, *Scleroderma diffusa* and *Scleroderma localis.*

Scleroderma Diffusa.—This is the affection described first, under the name of *sclérémie des adultes*, by Alibert, in 1817. The affection occurs most commonly in women and in adult life. No previous ailment seems to exercise a predisposing influence, unless it be rheumatism. The immediate cause in many cases has been exposure to dampness and cold.

The induration, which is so marked a symptom of the affection under consideration, is variously described in different cases, and writers seem to vie with one another in their attempts to express vividly the peculiar sensations offered to the sight and touch.

In some cases the skin is described as being of stony or board-like hardness, or feeling like that of a frozen corpse, without the sensation of cold. In other cases it is compared to brawn or leather. Adherence of the skin to subjacent tissues is not uncommon—"hide bound," or "perfectly immovable," are the expressions used. In a case coming under the writer's personal observation, the skin over the forearms was so bound down that the limbs seemed as if carved out of wood. The underlying muscles, particularly those of the limbs, are generally more or less wasted.

One of the most distinctive characteristics of this variety of scleroderma is symmetry and diffusion as distinguished from localization. Commencing, as in most of the cases reported, on the back of the neck, the disease spreads equally on either side of the median line; or, when it begins in the limbs, both are usually attacked at once.

The surface covered is almost invariably large; those cases reported in which the disease seems to tend toward localization, are usually to be regarded as, in all probability, belonging to the other variety of the disease.

A marked characteristic of this variety of scleroderma is that no distinct boundary exists to the affected areas; they seem to melt imperceptibly into the surrounding skin.

The color of the affected skin varies much in different cases. In many cases pigmentation exists to various degrees, while in other cases the skin either retains its normal tint, or becomes pale-yellowish or waxy in color. A curious fact is that the pigmentation seems much deeper in the immediate neighborhood of the sebaceous follicles. In a certain number of cases, it is said that spots or patches of pigmentation at various points precede and presage the induration of the skin in these localities. This, however, is more likely to occur in the circumscribed and localized form of scleroderma.

Neither fever nor local inflammatory reaction of any kind ushers in, accompanies, or follows the appearance of the disease in any typical case. Œdema is rarely, if ever, observed in diffuse scleroderma. Occasionally swelling of the hands or feet has been observed as a result of mechanical interference with the circulation.

The rapidity with which the disease attacks and spreads over the skin varies in different cases. In some, large areas of skin become indurated in a very short time; in others, the onset is slow and insidious.

In no case is there any marked elevation of the indurated skin above the level of the surrounding and unaffected parts, though tubercular elevations have occasionally been observed. Where the tightened skin plays over prominent bony parts, as the knuckles, a tendency to ulceration is often observed.

Cutaneous sensibility in most cases remains unaltered. The appendages to the skin, the glands and hair, are rarely affected.

Scleroderma diffusa runs a very chronic course; many cases may be under observation for years with little or no change apparent, and this under the persistent employment of decided and varied treatment. The existence of scleroderma does not necessarily exclude that of other skin diseases; acne, comedo, and eczema have been observed simultaneously, and in the same localities.

Scleroderma diffusa is not in itself a fatal affection. In the few cases in which death has occurred while the patient has been under observation, it has usually occurred from some intercurrent disease, totally unconnected with the scleroderma. It is true that, in one case recorded, death was hastened by the extremely inflexible condition of the facial integument, which interfered

greatly with deglutition, while in some others respiration was much impeded through immobility of the thoracic walls.

The pathological anatomy of scleroderma diffusa is simply that of a hyperplasia of the fibrous element of the papillary layer and corium, with decrease of subcutaneous fat and increase in pigment deposit.

SCLERODERMA LOCALIS.—The symptoms and course of this disease, or form of disease, are very different from those of scleroderma diffusa. The affection is sometimes preceded by nervous symptoms, neuralgic pains, rheumatism, etc. At other times there are no general prodromes. The advent of the local symptoms is usually insidious, so that they are not often observed until the disease has made considerable progress. The most prominent skin symptoms are the appearance of parchment-like patches, with sclerotic striæ. In a typical case described by Bésnier the patches were irregular in shape, usually elongated in the direction of the axis of the body and members, isolated or confluent, sometimes symmetric, sometimes asymmetric. At first sight these patches can be distinguished from the surrounding skin only by their deeper color, their finely striated surface, slightly depressed beneath the level of the surrounding skin, and particularly by a lilac border composed of fine blood-vessels.

To the touch the affected patches seem slightly rough, dry, parchment-like, and superficially indurated, so that the skin can be pinched up only in thick folds. Sensation is in no way altered.

The striated patches are sometimes fine and diffuse, and hard to recognize, at other times they are united, forming large patches of convergent stripes.

The localized patches of scleroderma may be observed in any part of the body, but are more common on the trunk. The cases which have been observed by the writer have presented only the parchment patches (morphœa) with lilac areola, and have been observed about the clavicles and on the face.

In addition to the more characteristic patches above described, keloidal lesions and areas of pigmentation are observed at times. Occasionally also ecchymoses and phlyctenular lesions occur, and hyperæsthetic points, but these are usually evanescent. In some cases deep-seated and superficial neuralgic pains precede and accompany the appearance of the lesions, occurring in attacks often nocturnal. In other cases no such symptoms are present.

Accompanying the skin symptoms, rheumatic pains with articular symptoms, anchyloses, and even osseous degenerations have been reported. The hands and fingers, in particular, are said to be involved. The disease runs a very chronic course, and but few cases have been followed through their entire evolution. It will be seen from the above description that scleroderma, whether of the diffuse or localized form, presents itself in so many varieties as to make it difficult of definition. As to the nature of the localized form, all the evidence points toward a tropho-neurotic origin.

Arthur Van Harlingen.

SCROFULODERMA. There are a number of skin diseases so closely connected with the condition of the system called scrofulous as to be properly designated *scrofulodermata.* Of these, one of the commonest is that which begins in one or more of the superficial lymphatic glands, especially under the jaw, about the neck and clavicular region. The glands become enlarged and the process extends to the skin overlying them, which becomes red and infiltrated. Finally a cold abscess forms, and is discharged through the skin, and an ulcer of slow progress, with undermined violaceous border, results.

Bésnier calls scrofulous nodes, especially when they occur superficially, "scrofulous gummata," on account of their resemblance to syphilitic gummata. The most superficial of these gummata begins as a small infiltration or node in the skin, of a livid red color. Increasing in size, slowly at first, and later more rapidly, it sometimes extends in one or more directions, involving the entire skin, and softening at one or more points to form small ulcers, with burrowing sinuses extending from one to another. The discharge from these ulcers is usually sero-purulent or sanious, and occasionally bloody, and the skin may be undermined by numerous communicating galleries. Occasionally the disease takes on a diffuse, infiltrating form, spreading in an irregular patch over the skin, involving its entire surface, and giving rise to serpiginous shallow ulcers.

The scrofulous ulcer never shows any disposition to heal. It may look as if it were on the very verge of cicatrization, but it does not actually scar over, or, if it does, a week or two later the cicatrix may open in one place while forming in another.

In addition to the localities above mentioned, this form of scrofuloderma may occur over the cap of the shoulder, in the groin, and elsewhere. It is generally accompanied by other signs of the scrofulous condition, by old scars, etc.

This form of scrofuloderma is to be distinguished from lupus vulgaris and from syphilis by the concomitant general symptoms of scrofulosis and by the peculiar features of the lesions, which differ materially from those of lupus and syphilis. The characters of the primary lesions, the form of the ulcers and their course, and the amount of crusting differ materially. Where the diagnosis between scrofuloderma and syphilis is difficult, the history in some cases will aid.

Another and rarer form of scrofuloderma is characterized by the formation of papillary, wart-like, or fungous growths of a pale, bright, dusky, or violaceous red color. The surface of these growths soon ulcerates, with a thin discharge and some crusting. These lesions are apt to occur upon the backs of the hands, and may extend to such depth as to lead to bone-changes. The course of this form of scrofuloderma is exceedingly chronic.

A fourth variety of scrofuloderma may be referred to, which shows itself in the form of small, hard, scattered, flat papules with a raised violaceous areola. The lesions may occur upon any part of the body, but are usually met with upon the forearms, legs, and face. At first they look like the pustular syphiloderm, but crust over after some weeks, leaving a depressed pit-like cavity, of a size to receive the head of a pin, in the lesion. Finally the lesion disappears, leaving a punched-out scar like that of small-pox. This form of scrofuloderma is chronic to an extreme degree. New lesions form while the old ones are cicatrizing; and while the affection does not give rise to any pain or other annoying sensation, it is very rebellious to treatment.

The treatment of scrofuloderma is both general and local. Cod-liver oil, iodine—usually in the form of iodide of potassium, or of Blancard's pills of iodide of iron—and iron alone, are most frequently serviceable. Milton has reported excellent results from the administration of calomel or gray powder, two or three times a week at bedtime for a fortnight, with a saline every morning, so as to produce a daily action of the bowels. Then the mercurial is suspended for from a fortnight to a month, the saline being continued. If the appetite fails, bitters and mineral acids are to be given. Locally a mild zinc ointment is applied. Milton lauds this treatment as curing where all else fails.

Locally the ulcers are to be treated, as a general thing, with stimulating ointments, preferably those containing mercury. Ointments and powders of iodoform are also useful. Tincture of iron and chlorinated soda solution may also be used. Where the disease is extensive, scraping with the curette or sharp spoon, to remove the morbid tissue, as in lupus, is the quickest method.

[TUBERCULOSIS OF THE SKIN.—Our knowledge of tuberculosis of the skin is of recent date, and even now but little is known of this affection on account of its comparative rarity.

Tuberculosis of the skin usually shows itself as a single roundish or oval ulcer, which soon becomes crusted over, giving rise to little pain. On removal of the crust a reddish-yellow granular surface, bleeding easily, is observed. The walls of the ulcer are only slightly infiltrated, soft, not undermined, though sometimes movable

over the subjacent tissues. The edges are not smooth, but irregular and eroded, with occasional pits filled with pus. It is extremely rare to find any miliary tubercles.

The ulcer grows by gradual destruction of the edges in an irregular way, presenting occasionally a serpiginous appearance. The tuberculous ulcer is never large, rarely exceeding the area of ten to twenty square centimetres. It shows no tendency whatever to heal. The seat of the ulcer is almost always about some mucous orifice, as the mouth, anus, or vulva, or on the glans penis. The diagnosis is to be made by exclusion.

The treatment, in addition to that described above under scrofuloderma, consists in scraping and applying pyrogallic acid. The prognosis is usually unfavorable.

Arthur Van Harlingen.

SCULLCAP (*Scutellaria*, U. S. Ph.), *Scutellaria lateriflora* Linn.; order, *Labiatæ*. This genus consists of scentless bitter perennials, destitute of the aromatic properties found in most species of this large order, and further distinguished by a peculiar helmet-like development of the upper sepal, to which it owes its name. Calyx two-lipped, persistent; closed-in fruit until maturity, when it splits and opens widely. Corolla labiate, ascending; stamens four, also ascending, and under the upper lip of the corolla; lower anthers one-celled. Leaves opposite, petiolate; flowers axillary, usually solitary, sometimes in apparent spikes or racemes. There are about ninety species, forming a very distinct and natural genus, distributed over nearly the whole north temperate zone. There are about a dozen in the United States. The above-named species is a branching herb, from one to two feet high, with small flowers arranged in one-sided racemes, whose floral leaves are reduced, excepting those near the base, to small bracts. It has opposite, ovate-oblong or lanceolate, coarsely serrate, pointed leaves about two inches long. Stems squarish.

The commercial Scullcap is the entire herb, or the leaves and branches, dried. It has but little odor, and a bitterish taste. Both this and other species of *Scutellaria* have had from time to time some transient or popular reputation in medicine for the cure of mad-dog bites, chorea, epilepsy, or other nervous diseases; also as tonics, antiperiodics, etc. The present species, *S. lateriflora*, is considerably used by the Eclectic school of practitioners, and in home medication. It is reputed to be antispasmodic, anticonvulsant, etc., and is given for restlessness and wakefulness. Its composition has not been determined, and there is nothing in its obvious action to indicate that it has any particular value. Dose from five to ten grams (ʒ j. ad ʒ iij.).

ALLIED PLANTS, ETC.—See PEPPERMINT. Lycopus resembles it in properties. *W. P. Bolles.*

SCURVY, or SCORBUTUS. Philologically considered, the word "scurvy" appears to be of North country or Scandinavian origin, being derived from the Swedish *skörbjugg*, or the Danish *skojærbug*, signifying soft or relaxed stomach, the relaxation of the abdomen being one of the characters of this malady. The German *scharbock* and English scurvy have the same sense. As the disease, scurvy, prevailed among the ancient Danes, it is probable that they have given us the word, which, together with numerous other technical terms applied to navigation, has left an imprint on our language showing plainly the Viking influence.

Symptomatic definitions of scurvy are almost too well known to require repetition. On running over a number of them, selected at random from standard works, three distinct points are fixed in the mind, namely: 1, Skin and muscle lesions; 2, mouth and gum phenomena; and, 3, physical, physiological, and psychical depression. Besides this, the definitions agree in attributing the alteration of the blood to a defective alimentation. Many writers speak of scurvy as a nosohæmia of the same nature as purpura, from which it differs in greater intensity only. However strange the statement may seem, scurvy should properly be classed with the condition of multiple neuritis known as beriberi. The two diseases do not resemble each other in all essential points, yet we see in beriberi the result of insufficient alimentation brought about by the abuse of a vegetable regimen, and the absence of meat, salt, and fat, and one that is best treated by butter, cocoanut oil, and fat meats; while scurvy, which originates from the abuse of an animal regimen and the absence of fresh vegetable matter, is cured most readily by a diet of fresh succulent vegetables.

Few diseases have been more observed and written about than scurvy, and few have so exercised the sagacity, and sometimes the imagination, of medical writers. The bibliography of the disease is enormous, and, so far from settling mooted points in the pathology of scurvy, it only adds to the confusion.

To write the history of scurvy would almost be to write the history of medicine and to chronicle the sanitary circumstances of most human events, since the disease has occurred from time immemorial both on sea and on land. (See Army Diseases.) To pass in chronological review the various epidemics of scurvy of which a record is preserved would serve no good purpose. The disease was often described, but the first use which we find of the present name was in the sixteenth century, when a learned botanist, Enricus Cordus,[1] says of an antiscorbutic, the *Chelidonium majus*, "Saxones vero Scharbock's-Kraut (eam nominant), quod forte morbo quod illi Scharbock nominant medeatur." From this period clinical pictures of scurvy, more or less exact, occur in various publications up to the time of the appearance of the magnificent works of Lind, of Krebel, and of Mahé. The word "scurvy" is no longer on the "Statistical Reports of the British Navy," and Sir Thomas Brassey says that the disease has been unknown for eighty years in the Royal Navy, or in the better class of merchant ships.[2] With the opening of the Suez Canal, the recent improvements in steam machinery, and better methods of preserving food, it is certainly humiliating to find that scurvy should occur in the merchant marine, as it has occasionally done within the last decade. The English Government has made energetic efforts to diminish and stamp out scurvy from its commercial marine, and these efforts have been nobly upheld by *The Lancet* and the English medical press generally. Yet the high naval authority quoted above informs us that of late scurvy has been by no means rare in the British merchant service. A naval medical officer tells me that he knows of the occurrence of a number of cases of scurvy on board a British man-of-war on the South Pacific station, and that he has seen one case in the United States Navy. Dr. Guillemard reports the death of the boatswain, from scurvy, on board a well-found English yacht cruising in the Malay Archipelago in 1883.[3] Cases of scurvy have also lately come to the notice of the United States Marine Hospital Service. Four cases are reported from the Marine Hospital at San Francisco, in 1880, with one death, and another death from the same cause is reported in 1881. Both cases were complicated with pneumonia. Six cases were received into the Contract Hospital at Astoria, Ore., in 1881, and in 1885 the barkentine William Phillips, from Iloilo, Philippine Islands, arrived at Norfolk, Va., with scurvy on board. During the year ending June 30, 1887, the following cases of scurvy were treated in the United States Marine Hospitals: At Boston, 6; Chicago, 1; Port Townsend, 1; San Francisco, 4; Vineyard Haven, 2; and Wilmington, N. C., 1. Of this number 12 recovered and 3 improved. Only a few years since I had an opportunity to study, in the Baltimore Infirmary, a number of cases from a vessel that had come around Cape Horn. In the spring of the year 1887, in the remote parish of Hornstrandir, Iceland, 62 out of 400 died from typhoid fever. After the fever had worn itself out, Hornstrandir was attacked by scurvy, with several fatal cases.

While the existence of beriberi corresponds more or less to the geography of insufficient alimentation, scurvy may be said to have no distinct geographical limits, since its symptoms are likely to appear on land or at sea, in the tropics or at the poles, under diametrically opposite meteorological states, when the conditions necessary for its development are present. The polar regions have long

been regarded as the principal home of scurvy; but the geographical voyages of Kotzebue through Behring Strait (1815, 1818); that of Sir John Ross to the Arctic, accomplished without the loss of a man; and that of the late circumpolar expeditions, among which scurvy did not appear, are an evidence of what sanitary and preventive measures may do to ward off the effects of extreme polar cold.[4] On the other hand, numerous facts attest the existence of scurvy in such warm places as India, Aden, Hindustan, Brazil, Egypt, Algeria, and Senegal. In the arid plains on the way to California, before the days of the Union Pacific Railway, emigrants were often attacked with scurvy, and entire caravans would perish from this cause. In late years almost the same thing has occurred in Australia. I have also seen it on the Rio Grande River in Texas, among persons whose diet was mainly beef and black coffee. In fact, having to subsist for some time upon the same diet, I had personal experience of the premonitory symptoms. Although we were surrounded by thousands of cattle, milk was not to be had, and we were also wholly deprived of fresh vegetables, on account of the extreme heat and dryness.

The foregoing observations show that this disease is by no means extinct, and that it may again become active whenever the conditions are favorable to its development. Nor is it confined wholly to the higher order of animals. I have seen the experiment of feeding two rabbits, one exclusively on meat, the other on vegetable diet. After a few weeks the animal fed on meat developed symptoms of scurvy, while the other was sleek and fat. Hogs, though growing fat on an exclusive animal regimen, become scorbutic. It has also been observed that monkeys and gorillas on board ship become scorbutic at the same time that the sailors are affected. It would be surprising, then, if the African should escape scurvy, as he was formerly supposed to do, when placed under the same conditions as his white brother. The fact is that the negro victims on board the slavers lived principally on vegetable diet, such as manioc, while the crew lived on salt provisions, and in addition had to contend with the circumstances of a previous voyage. The blacks, when subjected to the same dietetic causes as the whites, contract scurvy with them, as is shown by the history of sieges when both races had to live on the same food. Scurvy, therefore, is impartial in the selection of its victims; nevertheless, it would seem to be a disease of civilization rather than of primitive life, since it appears to spare degraded savages who subsist on roots and grubs, and Eskimos and Kamschatdales, whose diet is highly nitrogeneous.* Properly speaking, scurvy is not a disease of famine. The Terra del Fuegan and the African negro may starve from want of vegetable food, but they do not die from scurvy. On the other hand, according to Parkes, men fed on a uniform diet of fat have gained in weight but have become scorbutic.

Regarding the etiology of scurvy two sets of opinions prevail. The first admits but one cause in the production of the malady, viz., the prolonged deprivation of fresh vegetable food; the second admits a variety of causes—physical, moral, and dietetic—which may produce scurvy when combined, or when one or the other of them is associated with some adjuvant cause of a different nature.

Generally speaking, scurvy is engendered by the persistent and prolonged action of causes susceptible of weakening the metabolism of the general nutrition. And doubtless there are many causes which may contribute to this.

Among physical causes may be enumerated the rotation of the seasons, overcrowding, and excessive fatigue, or its opposite, enforced immobility. Other considerations being equal, humidity of the atmosphere favors the development of scurvy. Numerous reports by different authors show that dampness and atmospheric changes constitute the most invariable elements among the predisposing and exciting causes of scurvy. Epidemics of scurvy have prevailed among soldiers living in cold, damp casemates, though provided with a suitable ration; it has appeared on board ships and in fleets where fresh provisions abounded—for instance, in the squadron of Admiral Martin cruising in the English Channel; and the bad weather experienced in doubling the Cape of Good Hope or Cape Horn has, for a long time, been recognized as one of the causes of scurvy. Of course it would be imprudent to say that cold and damp, overcrowding, or any one of the forementioned causes is an indispensable factor in the outbreak of scurvy. They may have acted like sparks in lighting up the effects of a train of previously existing unhygienic circumstances.

Fatigue is mentioned by most writers as an adjuvant cause. The assertion finds its application in the instances of overworked and underfed prisoners, in the disastrous retreats of armies, during sieges, in shipwrecks and disasters at sea. Among recent examples is the outbreak of scurvy among the enfeebled men of the Spanish squadron returning from the bombardment of Callao.

Immobility or inaction, whether forced or voluntary, takes a part in the genesis of scurvy. It has often been observed in prisons and asylums. The crews of ships doing blockade duty have been attacked with scurvy, which has disappeared as if by magic on making preparation for an engagement or on going into battle. According to Dr. Charles Smart, United States Army, the average annual rate of cases of scurvy reported to the War Office during the eighteen years before the Civil War was 23.3 per thousand of strength, or nearly twice as large as that which prevailed among our white troops during the years of the war.[5]

To these causes may be added those referable to defects in lodging, bedding, clothing, and antecedent physical state. We may mention the filthy bedding in such dark, ill-ventilated places as the forecastle of most merchant ships as perhaps concerned in the causation, and it is well known that the excesses in which men indulge when ashore furnish a strong predisposing cause, so that men leaving port on a long-distance sailing ship, after a debauch, are more likely to acquire a scorbutic taint than those who have kept sober.

Next to the physical are the mental and moral causes. Psychological misery and moral depression in prisoners have long been looked upon as preponderating causes, and in years gone by nostalgia was thought to have caused scurvy on board French ships. A comparatively recent example, in which the alimentary origin cannot be admitted, is the outbreak of scurvy among French prisoners at Ingolstadt (1871), who, according to report, received excellent rations of fresh meat and potatoes. In this instance the malady was thought to be owing to the damp cold of the casemates, to inactivity, and to mental depression. Deported convicts and prisoners on board ships have also suffered from scurvy, though receiving the same ration as the crew. Notable instances of late years are the epidemics of scurvy on board the French transports which conveyed political convicts to Caledonia in 1873. On board the Var and the Orne the food of these unfortunates is said to have been irreproachable as to quantity and quality; they received exactly the same ration as the crew and the free passengers, except that they had only half a ration of wine and no brandy; the drinking water was excellent, and clothing and bedding were sufficient. But chagrin, want of employment, ennui, and painful preoccupation affected the prisoners, and they slept in a vitiated atmosphere that was damp and hot. Recent travellers also speak of the prevalence of scurvy among Siberian prisoners.

Physical and moral causes may together engender scurvy, more particularly after prolonged and uniform usage of salt provisions that have undergone an isomeric modification that causes a loss of their reparative properties. Salt in itself is, however, not a cause of scurvy. The experiment of drinking sea-water for a month has been followed by harmless results, and numerous instances are reported in which the prolonged use of salt provisions has not been followed by scurvy. On the other hand, we have examples of the outbreak of the mal-

* It has been suggested that the marked absence of salt may account for this immunity. Having spent two seasons among the Eskimos of Behring Strait, I have been impressed with the fact of their aversion to all salted articles of food.

ady in cases in which salt food has not been employed. Yet it cannot be denied that the chief cause of scurvy is to be found in the absence or the insufficient quantity of certain materials or principles necessary to good alimentation, and notoriously in the prolonged deprivation of milk, and of fresh vegetable food. Epidemics of scurvy in English and Scotch prisons have often been attributed to the privation, or to the suspension, of the ordinary ration of milk served to the prisoners. The uniformity and monotony of the diet in most merchant ships are not conducive to the preservation of health. Sir Thomas Brassey says the allowance differs little, except in quantity, from the dietary in use during the last century; and this notwithstanding the great improvements in the preservation of meats and vegetables. The abuse of tobacco is also claimed to be a pathogenic factor in scurvy.

For convenience of description the ordinary phenomena of scurvy may be divided into three degrees or periods. The first period, that of evolution, is marked by general adynamia. The physiognomy is expressive; the characteristic pale-yellow tint of the skin being distinct from that of icterus, or of any other cachexia. Extreme lassitude, with an undefinable sensation of malaise in the voluntary muscular system, is accompanied by a sad and downcast air, disturbance of the appetite, dyspnœa, insomnia, hebetude, and other indications of diminished vitality. These are followed usually, though not always, by gingivo-buccal symptoms. At the margin of the gums, and in the intervals of the teeth, appears a change of color and consistency, owing to alteration of the capillaries; the gums become livid, soft, and bleeding; and the breath has a characteristic earthy, fetid odor. Pains occur in different parts of the body, more particularly in the lower limbs, and extravasation of blood in the outer skin and other tissues causes small purpuric spots that often assume a large size and induce a brawny hardness in the cellular tissue of the legs.

In the second period these symptoms are greatly aggravated. The purpuric spots become true ecchymoses, varying in color from yellow-brown to blue-black; the sanguineous infiltration, affecting the muscles of the calf and thigh, causes a characteristic induration; the loosened teeth sometimes fall out; and the alteration may extend to the osseous system, causing detachment of the epiphyses, if the subject is young, and sometimes exostosis and periosteitis. In addition to these, there may be bleeding from the mucous membranes, painful dyspnœa, a relaxed and pendulous condition of the abdomen, and fever.

In the third or last period the aspect of the patient is that of a breathing cadaver. In addition to the fever and other symptoms already described, there follows a general prostration, with septic or putrid hæmorrhages; the legs assume a sphacelated appearance; phlyctænæ are followed by rapidly extending and spontaneous ulcerations of the skin; fractures which have long been united again separate; necrosis of the tibia and bones of the foot occurs, and marasmus supervenes. Death occurs from extensive suppuration, from the intensity of the hectic fever, or by hæmorrhage, visceral lesion, or syncope.

So little is known of the pathological lesions of scurvy that the subject may be dismissed in a few words. Although the disease is dependent upon some chemical alteration in the quality of the blood, it cannot be said that we know positively of any morphological modification of this fluid that is proper to scurvy. The same may be said of the other morbid changes that have been noted. Beyond the sanguineous effusions into the splanchnic cavities; softening, or more often hardening, of the muscles; the occasional cartilaginous detachment of the ribs, and caries of the bones, scurvy has no anatomical characteristics that are not common to many other diseases.

It is rather in the complications of scurvy that the more marked anatomical lesions are to be found. To study even the more immediate of these complications would require systematic examination of most of the organs of the body, since pleurisy, pneumonia, pericarditis, etc., are morbid processes occurring side by side with scurvy under the influence of accessory causes; and many great epidemics of disease, especially in armies, have been preceded, accompanied, or followed by scurvy. In fact, scurvy may color or modify many diseases or accidents, prolong convalescence, and increase mortality to a serious extent. The most common complications of scurvy are dysentery, diarrhœa, and malarial fever, which some regard as epiphenomena of the disease. Hemeralopia and nyctalopia have a like origin with scurvy, and the pathological annals of navigation of the last two centuries are filled with the disastrous associations of the forementioned diseases.

If properly treated an uncomplicated case of scurvy leaves no trace. Many ex-soldiers are, however, borne on the Invalid Pension List on account of the results of scurvy incurred in the late Civil War. In these cases the chief sequelæ are loss of teeth, scars from extensive ulcers, and occasional lesions of one or more of the thoracic or abdominal organs.

Simple, uncomplicated cases of scurvy often disappear, as if by magic, on removal of the cause; but the reparative process is ordinarily slow, and severe cases require two months' treatment. The patient may be considered out of danger if, after several days of treatment, he regains the use of his limbs and has no dysentery, chest complication, or bleeding at the nose. An improved state of the skin is also a favorable indication. The prognosis, however, depends on the intensity of the symptoms; upon previous or concomitant diseases, such as fevers and lesions of the digestive organs; upon prolonged treatment for syphilis; upon malarial poisoning; upon the fact of a previous attack; and upon atmospheric and climatic conditions.

The diagnosis of scurvy is a matter of no difficulty. Perhaps some distinction should be made between it and purpura and Alpine pellagra, in order to avoid nosological confusion. The only morbid conditions with which scurvy is likely to be confounded are the different anæmias and spanæmias, hæmatophilia, beriberi, and the cachectic condition brought about by dirt-eating. (See Appetite.)

No disease is more easily prevented, and none is more amenable to treatment than scurvy. The means of its prevention are now so well understood that an outbreak of scurvy among soldiers, sailors, prisoners, or the inmates of an asylum, or among any other persons subjected to discipline or restraint, is, in most cases, presumptive evidence of neglect on the part of somebody. The law takes cognizance of this neglect, as is shown in Sections 4,569 and 4,570 of the Revised Statutes.

The prophylaxis of scurvy is so apparent, after its causes are known, that to particularize the details would be to repeat unnecessarily.

Regarding the prevention of scurvy, the most efficacious hygienic precepts are now a matter of common knowledge. The principal ones that bear emphasizing are the enforcement of dryness and cleanliness, especially on the berth-deck or forecastle of a ship, and the use of so-called antiscorbutics. We have no rational explanation of the power of the latter as a preventive; their use being in the large and true sense purely empirical. New Bedford whalers cruising in the Pacific Arctic provide themselves with a sufficient supply of live pigs, cocoanuts, pickled cabbages, onions, and potatoes. From the captain of a Russian fur-trading vessel I learned of an excellent antiscorbutic in the use of cranberries, especially the little ones that grow in Alaska and the Aleutian Islands. Lime-juice, in great renown with the English, has won for them the sobriquet of "lime-juicers" from Yankee sailors. It is, however, very unpopular among many sailors, because they think the use of lime-juice causes impotency; and it is doubtful whether it be as effective as a liberal allowance of potatoes, onions, sauerkraut, and condensed milk, or the occasional issue of beer, cheap light wine, or even wine of absinthe, the three latter being regarded by Lind as antiscorbutics of the first order. The same authority also recommends eating a bit of raw onion every morning before exposure on deck. When practicable, cider may be added to the dietary, and

the daily use of lemonade at dinner is to be highly commended.

The curative treatment of scurvy being almost entirely hygienic, but little is to be done in a therapeutic way. Admirable results may be obtained from a good dietary consisting chiefly of milk, vegetables, and fruit. (See Grape Cure.) A chlorinated or an antiseptic mouthwash; an alcoholic or a camphorated lotion for the purpuric spots; the administration of brandy or quinine to overcome adynamia and cardiac insufficiency; and rest in a horizontal or sitting position, in order to avoid possible syncope, are the salient and essential therapeutic points to be observed in ordinary cases. The treatment of complications and sequelæ should be mainly directed against the asthenic condition, and so the economy should be fortified against a return of the disease, which may happen on the slightest provocation.

For the future observer there still remains much to be done in clearing up points of disagreement and in filling up the gaps left in the pathological anatomy of scurvy. To this end the newer experimental methods of investigation—chemical, clinical, and histological—should be made to take the place of the old hypotheses and sterile reasonings of our forefathers. In spite of numerous efforts, much remains to be done in the way of investigations bearing upon the component elements of the *blood*, such as a rigorous enumeration of the red globules, the amount of hæmoglobine in the corpuscles, and the chemical analyses of the globules themselves. In addition, it is desirable to know the proportions of iron and potassium, as well as of the principal substances eliminated by the excretions, particularly the urine. A better and more extended study of the state of the capillary system in the principal organs and tissues is a desideratum, and the same may be said of the study of the pathological anatomy of the principal viscera of the abdominal cavity. On the side of the nerve-centres almost nothing has been pointed out up to the present in the pathological anatomy of scurvy, and we are equally ignorant of the anatomical changes that occur within the organs of sight. *Irving C. Rosse.*

[1] Botanologicon. Colon, 1534.
[2] The British Navy: Its Strength, Resources, and Administration, vol. v., p. 174. London, 1883.
[3] Cruise of the Marchesa, vol. ii., p. 353. London, 1886.
[4] See writer's "Cruise of the Corwin to Alaska and the Northwest Arctic Ocean." Washington, 1881.
[5] Medical and Surgical History of the War of the Rebellion.

SEAL, GOLDEN (*Hydrastis*, U. S. Ph., Yellow Puccoon, Yellow Root, etc.). The rhizome and rootlets of *Hydrastis canadensis* Linn.; order, *Ranunculaceæ*. This is a low perennial herb, with a tuberculated, crooked, yellow rhizome, marked along its upper surface with frequent scars (seals) of fallen stems, and bearing numerous wiry, wavy, or crooked, yellow roots. The aërial stem, situated at the extremity of the rhizome, and surrounded at the base by a few brown scales, is upright, from two to three decimetres long, and bearing two unequal five- or seven-lobed leaves. The lower of these is the larger, and petiolate; the upper is sessile; flower solitary, terminal, about as large as a buttercup; it consists of three fugacious, greenish-white sepals, numerous stamens, and about a dozen pistils; fruit a raspberry-like cluster of red berries. Hydrastis grows abundantly in the northern and western parts of the United States and in Canada. In New England, and the Middle and Southern States it is more scarce. It was originally used by the Indians as a dye and medicine, and has been known to us about a hundred years.

Description.—It comes in pieces four or five centimetres long, slightly branched, or simple, covered with rather numerous rootlets, yellowish-gray outside, bright yellow within; the rhizome is slightly wrinkled longitudinally; odor strong; taste very bitter. The principal active derivatives of Hydrastis are the alkaloid *berberine*, the same as that found in Barberry Bark and other plants, and *hydrastine*. This latter substance, discovered about 1852, crystallizes in brilliant, white, four-sided prisms, soluble in alcohol, chloroform, and ether, but scarcely at all in water. No odor; taste, in solution, bitter. A third alkaloid, *xanthopuccine*, appears to exist in the drug, but is less fully known than the others. The proportion of hydrastine in the dried root is about one and a half per cent. An *odorous principle* and a *resin* have not yet been isolated.

Action and Use.—It is difficult to find in Hydrastis anything more than the usual tonic qualities of the *berberine*-yielding drugs; in small doses they all are thought to improve the appetite and promote assimilation; in large ones they derange the stomach. It is given in intermittent and other fevers, and for the various uses to which quinine is put—sweating, typhoid, diarrhœa, etc. Locally used, Hydrastis is in considerable favor as an ingredient of urethral and vaginal injections, as well as for washes for other surgical cases—ulcers, hæmorrhoids, vegetations, etc.

Administration.—Hydrastis is not often given in substance; the dose would be from three to ten grams. A Fluid Extract (*Extractum Hydrastis Fluidum*) and Tincture (*Tinctura Hydrastis*, $\frac{1}{5}$) are officinal. An infusion may be also made. For a wash or injection hydrastine and berberine are both to be had; doses from two to ten decigrams. "Hydrastin" is an impure preparation obtained in the usual way for "resinoids;" it is a combination of the three alkaloids and some resinous substance. Dose about three decigrams.

Allied Plants.—See Aconite.

Allied Drugs.—Coptis, Barberry, Columbo, etc.

W. P. Bolles.

SEA-SICKNESS. The assemblage of morbid symptoms denominated sea-sickness, or more properly sea-illness, is too well known to require formal definition, since there are but few that have not had both subjective and objective experience of the malady.

In spite of the distressing character of sea-sickness it fails to elicit much pity from others. It is also strange that the unpleasant phenomena of sea-sickness have been so little elucidated; such little advancement having been made in the study of the subject that it is practically a fresh one with an unlimited field of observation, and he that succeeds in working it will reap the reward of a public benefactor. The great medical writers of antiquity scarcely allude to sea-sickness, and the published observations of sea-going surgeons are most meagre. The majority of writers on the subject have been landsmen who knew but little of the sea, and sailors who knew less of medicine. In fact, the subject has been so little scrutinized by physicians, that it presents the remarkable anomaly of the existence of an ailment almost without a medical bibliography, the two hundred or more references to this subject consisting chiefly of a few theses or inaugural dissertations and short journal articles. It is rather to general literature that one must turn to find illustrations of the subject. Plutarch appears to be the first author to describe its symptoms and treatment. The malady is also mentioned by Suetonius and Juvenal, and every school-boy knows of Cicero's desperate resolve to fall into the hands of his executioner rather than endure longer the horror of sea-sickness. In Burton's "Anatomy of Melancholy" sea-sickness is mentioned as being very good at times; in Boswell's "Johnson" the great doctor recommends the salutary effects of a smart sea-sickness; Goldsmith interested himself to the extent of attempting to invent a machine for its prevention; in "Tristram Shandy" the cerebral effects of the malady are felicitously described; and so citations might be extended indefinitely from the "quite, quite down" of Shakespeare to Browning's "swooning sickness on the dismal sea," not to mention the comments of Rabelais and Montaigne.

Most of the attempted explanations of sea-sickness are pure figments of the mind, that of the greatest German *savant* being, in point of fact, but little above that of the humblest fisherman. It is, however, generally conceded that the symptoms are owing to the influence of the motions of the ship, which admit of infinite variation, as anyone may observe while sitting on the quarter-deck, or

when lying in a bunk, during rough weather. In endeavoring to balance or right itself, the ship rolls, pitches, seems to pause, and then darts with a side motion fore-and-aft, or, in more precise language, a variety of oscillations take place around both the transverse and the longitudinal axes of the ship. These motions alone are the cause of sea-illness, and bad smells, heat, sight of the waves, fear, "biliousness," and other alleged causes are mere accessories. The same idea, aphoristically expressed more than two thousand years ago, does not admit of greater refinement, notwithstanding the advanced knowledge of the day.

There are, however, certain unusual and disorderly movements that may cause phenomena similar to those of sea-illness, such as the trembling of the earth during a volcanic eruption or an earthquake, experiences of the kind having been common during the late seismic disturbances at Charleston and Mentone. Riding backward in a railway train, going up and down in a lift or in a balloon, the act of swinging, riding a camel or a dromedary, rapid gyratory movements of the body, the concussion experienced by workmen in riveting boiler-plates, or, in short, any series of unusual and disorderly shocks that disturb the cerebro-spinal or the ganglionic nervous system may bring on this peculiar functional disturbance.

It is estimated that of those who go to sea about three per cent. are never sick, and three per cent. are never well. Others, after temporary illness, recover rapidly; a few are prostrated for weeks, and, in rare instances, some delicate or susceptible persons may never recover. There is also much that is odd and enigmatical regarding individual susceptibility to sea-sickness. Although women are more subject than men, it sometimes happens that a delicate, hysterical girl will escape illness, while a strong man is prostrated. Champion pugilists during a voyage at sea have been overcome, while many of the weaker passengers were exempt. One of the greatest sufferers I have ever known was a celebrated member of the London Athletic Club. The liability to illness is much affected by the class of ship and by certain motions. Many persons will cross the Atlantic with impunity, and yet get ill on a Channel steamer. The sensibility of others is such that travel on a comparatively smooth river or lake causes unpleasant sensations. As a rule, navigation is easiest on a sailing-ship; the tendency to illness is increased on board a paddle-wheel steamer, and it is greatest on board a screw steamer. If the force of the wind should cause a list in the steamer to one or the other side, the tendency to become ill is greater. I have often noticed, in a transatlantic steamer, that passengers who had recovered from an illness incurred during a fore-and-aft motion of the ship, with the wind astern or off the quarter, would invariably become ill again when the wind shifted so as to cause a beam-sea, which changed the direction of the ship's oscillations. Owing to the greater amplitude of the oscillations experienced in going aloft, I have often seen boys become ill on board a training-ship, who kept well as long as they remained on deck. After staying ashore for some time, the inuring process of getting one's sea-legs has often to be repeated, even in "old sea-dogs." Some years since, in a gale on the Pacific, just after quitting the Golden Gate, I was a fellow-sufferer with an old Nantucket whaling captain; and though having personal claims to being something of a sea-rover, I lately became squeamish on board a steam yacht while witnessing a race. Nothing dampens enthusiasm like sea-sickness. Men full of military ardor start on an expedition, and after a day or two at sea on board a transport suddenly come to the conclusion that there is really no cause for war. History tells how Bonaparte's sea-sickness paralyzed and brought to naught his grand enterprise of invading England.

Many professional sailors suffer greatly from sea-sickness, and even Nelson was a martyr to this cause. I know of several naval officers who are great sufferers; one, a fleet captain, tells me that he often, in his cabin, suffers agony on this account. With many persons the susceptibility is so great that the sensorial perversions continue for days after going ashore, and in others anything suggestive of the sea causes unpleasant sensations. I have known such to be caused by a boatswain's whistle. A naval officer of my acquaintance, who is sorely troubled by this form of illness, has all the premonitory symptoms on the reception of his orders for sea duty; and I know an old lady in New Bedford who is unable to look at the heaving figure of a ship on the face of an old-fashioned clock without becoming ill. Another instance, in which the mere recollection of the occurrence caused renewal of the nausea, is that of the late Henry Ward Beecher, who relates that, many years after his first voyage across the Atlantic, he heard some sailors in a Brooklyn dock singing the same old "chanty" song that he had heard when ill at sea, and that the mere listening to this song produced symptoms of sea-sickness.

That something less than perverted sensation may arouse the unpleasant associations of sea-sickness is evidenced by the effects upon a highly susceptible person on reading one of Clark Russell's novels, say, "Wreck of the Grosvenor" or "Sailor's Sweetheart." Carried almost beyond the realms of fancy, one sees a complete nautical picture in his mind's eye; he hears the thud of the sea and the sounds of the running rigging; smells the tarred rope and bilge, and feels the close atmosphere and nauseating roll of the ship.

The cerebral action which recalls such phenomena can hardly be said to exist in the lower order of animals—such as birds, dogs, sheep, horses, and elephants—who often suffer greatly from sea-sickness. It is easier to look for a mechanical or physical cause in the disturbance of the cerebro-spinal fluid from the effects of a centrifugal force, analogous to the change that takes place in such a liquid substance as milk when placed in the tubes of a whirling machine for testing.

Similar effects of cerebro-spinal disturbance appear in a tumbler-pigeon, which seems lifeless after being whirled around for a few moments with the head under its wing; gulls, Mother Carey's chickens, and other aquatic birds, when placed on a ship's deck become nauseated from the rolling and pitching, that is to say, from the great oscillations of the ship around its axes; and many persons have observed the phenomena of sea-sickness in children who have ridden too long on a merry-go-round.

The many explanations that are offered to account for the symptoms of sea-illness differ one from another, and are all more or less objectionable. One of the causes assigned to account for the nausea is neither the motion in itself nor the appearance of motion, but the violation of the habitual conceptions of contrasted effects of motion, which may obtain not only in those having sight, but in the blind. The motions of the ship cause mental concepts totally at variance with the ordinary experience.

Dr. William James, of Boston, states that deaf-mutes, as a class, are exempt from sea-sickness, and for that reason it is suggested that the malady does not occur in the case of destruction either of the auditory nerves or of their labyrinthine terminations, and that the semicircular canals are the probable starting-point of the affection. An illustrative instance is mentioned in which a person much subject to sea-sickness was entirely cured after receiving a blow on the head which crushed the mastoid process and caused deafness.

That there is some connection between aural defects and certain symptoms simulating those of sea-illness appears to be the fact. Such symptoms are at times observed when the Eustachian tube is obstructed, and still more commonly when there has been concussion of the labyrinth, or when the structures contained within this cavity have undergone pathological changes as the result of cerebro-spinal meningitis.

Whether the nausea be owing to irritation in certain states of defective aural mechanism; to irritation of the nerves of the eye caused by the apparent instability of all surrounding objects; to agitation of the abdominal viscera; to the continuity of the muscular contractions necessary for the maintenance of the equilibrium; to the pumping motion of the liquids of the body, analogous to the rise and fall of the mercury in a barometer; to reflex

action disturbing the medulla, the spinal cord, the solar plexus, and the splanchnic nerves, or to concussive impact resulting in cerebral anæmia and diminution of the brain mass, we are not in a position definitely to say. These are questions too subtile and problematical, but it is possible that there is more or less truth in each, and that the symptoms vary accordingly as the cerebral, the spinal, or the visceral contents are most acted on; so that in some, whose cerebro-spinal system is less resistant, the trouble experienced is headache, giddiness, and unsteadiness, rather than the vomiting and loss of appetite of others, whose organic nervous system is principally affected.

No illness is less harmful and sooner forgotten than is this. Ordinarily it passes off in a few days, leaving the patient none the worse for his experience. In fact, it is highly beneficial in many ailments, as affections of the liver and digestive organs, melancholia, certain kinds of mental alienation, and obstinate intermittent fever, which I have known to be broken up by this curative means alone when all others had failed; and were it not for the rare occurrence of death in persons suffering from some antecedent malady, and the alarming weakness and erethism produced in other delicate subjects, the matter of deciding whether there is any effective prophylactic or any infallible treatment that may ward off, alleviate, and abate the ravages and woes of this unpleasant adjunct of sea-travel, would scarcely occupy the serious attention of the physician.

As a rule, sea-sickness is dangerous in organic disease of the stomach, brain, heart, or lungs, and to pregnant women. All such should avoid sea-voyages. Hæmorrhages and hernia may occasionally result from the straining caused by the frequent vomiting, and defective nutrition may bring about great wasting of the body. Obstinate constipation, marked diminution of the urine, and occasional spasmodic contraction of the urethra, are among what may be called the complications of sea-sickness. In addition to these, sugar is sometimes found in the urine, owing to irritation of the diabetic centre in the medulla; convulsions may occur in some cases, and instances of temporary insanity from this cause are reported. I have seen one such case in a Frenchman in crossing the English Channel from Dieppe. Dr. Reynolds states that he has seen three cases.[1]

Pretended specifics for sea-sickness have not been wanting from the earliest times, and most of them, from old women's remedies down to the sort of liver-pad praised by Bacon, are as worthless as they are foolish. We do not know the contents of the box of which Shakespeare says, "If you are sick at sea, a dram of this will drive away distemper" ("Cymbeline," act iii., scene 4.) Nor was it perhaps so effective as the rope's-end formerly used on green midshipmen in the British navy; or the bucket of cold water that is usually dashed over sea-sick men on board whaling-vessels; or the treatment pursued in the case of boys on training-ships, who are supported by two other persons, if necessary, and made to walk the deck and swallow occasional spoonfuls of hot soup until they get well. Such heroic measures, of course, cannot be resorted to when dealing with delicate, susceptible people, invalids, and pregnant women, who make up the larger part of the passenger list of an ocean steamer; so recourse is often had to such drugs as chloral, opium, chloroform, amyl nitrite, and numerous other sedatives, most of which are of little more value than the colored spectacles, supposed to prevent sea-sickness, which were sold in large quantities, a few years since, by an enterprising individual in Cadiz to Spanish soldiers embarking for Cuba.

Although like advising a sufferer from toothache to be philosophical, it is best, if one must go to sea, to exercise his courage and force of will. He must keep up and show his stoicism by remaining in the open air, and eating at usual hours, regardless of the fact that the food is vomited. The vomiting, which, by the way, is not one and the same thing with sea-sickness, is often allayed by lying down and by swallowing crushed ice or small quantities of iced champagne. According to Dr. Coniat, of the Compagnie Générale Transatlantique, the rebellious vomiting is arrested with "prompt and evident success" after faradization of the epigastric region, combined with the external employment of a solution of atropia, the intensity of the current being graduated according to the susceptibility of the person and the obstinacy of the vomiting.[2] The debilitated stomach is soonest brought back to its normal state after drinking a little bitter beer, or eating an orange, a lemon, or other bland and delicate food; but, as a rule, all spirits, liquids, and sweets should be avoided, as they disturb the stomach and irritate the gastric mucous membrane to the extent of causing a predisposition to illness. A teaspoonful of Worcestershire sauce is often excellent in the earlier stages; and fat bacon, smoked herring, and curry will often stay down when other things are vomited.

Mechanical contrivances against sea-sickness, as tight belts, swinging beds, the Bessemer saloon, and the project of affording greater amplitude by connecting two or four vessels after the manner of a catamaran, have proved inoperative.

A course of exercise in a swing, with a view to preparing for a voyage, has proved as futile as the habit of taking medicine previously to embarking. No malady, in fact, has afforded a more ample field for polypharmacy, and none is more rebellious to treatment. In fact, there is no remedy for sea-sickness, and as long as men go to sea, so long will they be liable to suffer from this distressing malady. *Irving C. Rosse.*

[1] Lancet, 1884, i., 1161. London.
[2] Archiv. Méd. Navale, November, 1868.

SEBACEOUS CYST, or "wen," as it is popularly called, appears as a variously sized, firm or soft, roundish tumor, seated in the skin or subcutaneous connective tissue. The skin covering the tumor is natural in color, or whitish from stretching. The tumors may occur singly or in great numbers, and may vary from the size of a pea to that of a walnut, or larger. They are usually firm, but sometimes doughy, and are generally freely movable and painless. Their usual seat is upon the scalp, face, back, and scrotum, though they may be met with anywhere, even on the soles, it is said. They may last for years unchanged, but sometimes break down and ulcerate. They may degenerate into epithelioma in old persons. Some sebaceous cysts are flat, with a minute hole in the centre, others tend to rise above the surface of the skin and become semiglobular. The latter are those commonly found upon the scalp, when they are devoid of hair.

The contents of sebaceous cysts may be milky or cheesy in consistence, and are often decomposed and fetid. The tumors are, in fact, nothing more than enormously distended sebaceous ducts and glands, the walls of which have become hypertrophied until they form a tough sac.

The treatment of sebaceous cyst is excision. The cyst-wall should be carefully dissected out, as otherwise the disease is apt to recur. *Arthur Van Harlingen.*

SEBORRHŒA. A disease of the sebaceous glands of the skin, characterized by an increase in the quantity of sebum poured out; and also, in most cases, by an alteration in quality of the secretion. There are two varieties—*seborrhœa oleosa* and *seborrhœa sicca.*

Seborrhœa oleosa appears in the form of an oily coating upon the skin, giving it an unctuous and greasy feel. Its most common seat is on the scalp and about the face, particularly the nose and forehead, where it appears as a greasy coating, containing more or less dust and dirt, and looking as though the skin had been smeared with a dirty ointment. In the scalp it collects on the hair, giving it a dark, limp look, as if it had been freely oiled, or, when the scalp is bald, looking as if oil had been poured over it.

Seborrhœa sicca, or dry seborrhœa, occurs in infants as *vernix caseosa*, or smegma of the new-born. Here it is almost physiological, and is usually soon removed. If it remains it becomes a diseased condition, and as such is often seen upon the scalp. Dry seborrhœa shows

itself on both the hairy and non-hairy portions of the body as a more or less greasy mass of scales, of a dirty yellowish color, and somewhat adherent to the skin. On the scalp these masses are larger and oilier, tending to cling to the skin in thick plates, and leaving, when picked off, a smooth, grayish, moist or oily surface beneath. In old persons the scalp, and sometimes the region of the beard, is covered to a greater or less extent with a brown, adherent greasy coating, which is essentially seborrhœic in character.

Seborrhœa of the scalp, like pityriasis, with which it is sometimes confounded (see *Pityriasis simplex*), is sometimes followed in the young by premature baldness. If taken in time, however, baldness from this cause can be prevented, and it is desirable in all cases to remove the seborrhœic condition, even if it gives rise to little or no annoyance.

Seborrhœa of the foreskin and glans penis is an abnormal flow of the normal secretion of this part, known as *smegma præputii*. If not attended to, it leads to balanitis, from the irritation of its rapidly decomposing sebaceous products.

Seborrhœa is induced by a variety of causes, prominent among which is the chlorotic or anæmic state. It is more apt to occur about puberty or in early adult age. It may occur in persons otherwise healthy. In such cases it is usually curable by local measures.

The diagnosis of seborrhœa is usually not a matter of much difficulty, the evidently sebaceous character of the products of disease pointing out its nature with sufficient certainty. The treatment of seborrhœa should usually be both constitutional and local. Fresh air and exercise, especially in the case of young women, is to be insisted upon. Attention should also be paid to diet. The history should be looked into, and any functional irregularities corrected when possible. Success in treatment often depends upon ascertaining and meeting the exciting cause in the individual. Cod-liver oil, iron, and arsenic are the most generally useful remedies. Iron may be given in the form of the tincture of the chloride alone, or with phosphoric acid. Arsenic is best given as Fowler's solution, in the dose of four or five minims, thrice daily, in wine of iron. Cod-liver oil is particularly beneficial in cases in which oily seborrhœa is accompanied by acne, particularly acne indurata in strumous subjects.

The local treatment of the disease is very important. In seborrhœa of the scalp the scales and crusts must first be removed. If they are hard and caked, as is sometimes the case in old people, the scalp should be soaked in olive- or almond-oil overnight. Hot water and soap will then remove the softened crusts.

An excellent means of removing the crusts and scales is by means of the spiritus saponis kalinus, an alcoholic solution of Hebra's green soap. A tablespoonful of this may be applied to the scalp with a sponge and a considerable quantity of warm water added, so as to make a lather. After vigorously shampooing the scalp for a few minutes, the soapy matters are to be washed away with an abundance of clear warm water, and the scalp dried quickly with a soft towel, when it is ready for the application of the more strictly remedial agents, usually in the form of medicated oils. An excellent formula is the following:

℞. Acidi carbolici	Gm.	3 (gr. xlv.)
Ol. ricini	Gm.	4 (f ʒ j.)
Ol. limonis	Gm.	2 (f ʒ ss.)
Aq. cologniensis ......ad	Gm.	64 (f ℥ ij.)

On the bald scalp and other places where there is no hair an ointment of one part of sulphur to eight parts of cosmoline may be employed.

The prognosis of seborrhœa is generally favorable. The oily variety is that which is most apt to be stubborn under treatment. *Arthur Van Harlingen.*

SECRETION, PHYSIOLOGY OF. Secretion in general may be defined as the separation of certain products from the blood, usually in a liquid form, which are poured out on the free epithelial surface of the secreting organ. When the secreting surface happens to have a somewhat complicated structure it is usually spoken of as a gland. Simple epithelial membranes, such as the pleura or peritoneum, may, and often do, form secretions from the blood, and though not ordinarily described as glands, there is, nevertheless, no fundamental distinction between the process of secretion in them and in the more complicated secreting organs, such as the salivary glands. That is, in both cases we have to deal with secretions, as defined above, and though the secondary differences between the two are many, they are, perhaps, not more numerous than those which exist among the glands, usually described as such, in the body. Indeed, the phenomena shown in the action of the different glands are often so diverse that some physiologists are inclined to doubt whether any general theory of secretion will ever be obtained; but these differences, as well as the resemblances, will be better appreciated after the action of the various glands has been described.

Defining a gland as a secretory organ, the simplest form of gland that we have to consider consists of three essential parts, viz., (1) a simple basement-membrane, or membrana propria, supporting on one side a layer (2) of secreting cells, nucleated epithelial cells, and on the other side (3) a network of blood-capillaries, as shown in the diagram (Fig. 3417).

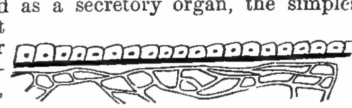


FIG. 3417.—Typical Secreting Surface. *a*, Basement-membrane; *b*, secreting cells; *c*, capillary network.

All the secreting organs of the body are constructed essentially on this plan; and the serous, mucous, and synovial membranes furnish examples of this simplest form of secreting apparatus. It is obvious, however, that if all secreting organs were constructed exactly in this way, as plain surfaces, the extent of the secreting surface would be greatly limited. The various complications of structure that we meet with in the different glands seem to have for their primary purpose economy of space.

A plain secreting membrane, such as that described, may have its surface increased, without occupying more space, in one of two ways. First, by protrusion in the form of folds. These folds or processes may be either simple or compound, according to the extent of surface demanded, as shown in Fig. 3418. Examples of this

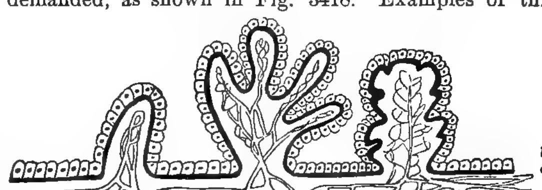


FIG. 3418.—Increase of Secreting Surface by Protrusion. *a*, Basement-membrane; *b*, epithelial cells; *c*, network of blood-vessels.

method of increasing the surface are found in the villi of the mucous membrane of the small intestines, and in other places, though this method seems to be one that is not generally used. Second, by a denting in of the surface to form a crypt or follicle. The cavity thus formed may be either tubular or saccular. Most of the glands of the body are formed on this plan, and may, therefore, be divided into two great classes—the tubular glands and the saccular, or, as they are more commonly called, the racemose glands (from *racemus*, a cluster of grapes). The invagination of the membrane may form only a simple tube or sac, making what is known as a simple tubular or racemose gland—as in the crypts of Lieberkühn of the small intestine, the sweat-glands, and some mucous crypts. Diagrams of this form of gland are shown in Fig. 3419. The increase in the extent of surface in these cases is not very great, unless, as in the sweat-ducts, the simple tube is very much elongated and twisted into a compact knot. The invagination, however, instead of

being a simple tube or sac, may be variously compounded, forming what are called compound glands, of which again we have two kinds—compound tubular and compound racemose glands—diagrammatic representations of which are given in Figs. 3420 and 3421.

In the compound racemose gland the separate little

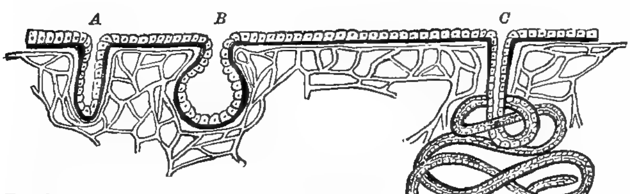


Fig. 3419.—Increase of Secreting Surface by Invagination. *A* and *C*, forms of simple tubular glands; *B*, simple racemose gland.

sacs are spoken of as alveoli or acini, and they open into canals or ducts which finally unite into one or more common secretory ducts. The salivary glands and pancreas are good examples of this type of gland, the secreting surface being enormously increased without any great loss of space. The different alveoli are united into lobules, and these, bound together by connective tissue, form the gland. The actual secreting cells are found in the alveoli, while the epithelial cells lining the ducts have, probably, simply a protective function. Examples of the compound tubular glands are found in the kidneys and testes, and to a less marked extent in the gastric tubules of the stomach. In the kidney and testes, by this subdivision of the tubular gland, a really vast extent of secreting surface is obtained within a very limited space. In such glands we can also distinguish a portion in which the epithelial cells have an active secretory function, from that known as the duct of the gland, in which the epithelial cells seem to form simply a protective covering.

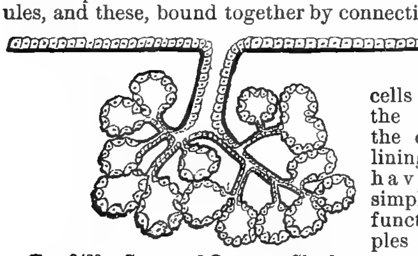


Fig. 3420.—Compound Racemose Gland.

It was formerly customary to divide the secretions into two great classes, viz., excretions and secretions proper. Johannes Müller, in his "Physiology," defined these two classes in this way · Excretions are substances which exist already formed in the blood, and are merely eliminated by the gland without being changed in the process—the urea of urine, for instance; while the secretions proper are substances which do not previously exist in the blood, but are first manufactured from it by the cells of the secreting gland—a good example of this type is found in the milk produced by the mammary gland.

It has as yet been found impossible, however, to establish any such distinction as this. Even in the case of urea it has long been doubted whether the kidneys simply eliminate this substance from the blood after it has been formed in other tissues, many contending that the cells of the uriniferous tubules take part in the formation of the urea. Indeed, the question may still be regarded as an open one, needing further investigation before decisive statements can be made.

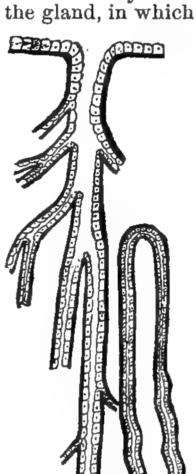


Fig. 3421. — Compound Tubular Gland.

The more usual conception of an excretion as a product, formed in a gland, which is of no further use in the animal economy, and is simply eliminated from the body as waste matter, while sometimes a convenient expression, is also inadmissible from a scientific standpoint. In the first place, we have secretions, such as the bile, which contain both waste products, of which no further use can be made, and also true secretory products of great functional importance in the body. In the second place, the method of formation of these so-called excretions—the urine, for instance—cannot be clearly separated from the processes of ordinary secretion. It will be better, then, to abandon any attempt to make a distinction between secretions and excretions, and to describe the processes in both cases under the general term of secretion, as is done in the best text-books of physiology at the present time.

Another classification of secretions that has been suggested divides them into transudations and secretions proper. By transudations we mean those secretions which can be conceived as derived from the blood by the simple physical processes of filtration and diffusion. Examples of this are found in the secretions formed on serous membranes—the pericardial liquid, or that in the tunica vaginalis of the scrotum, for instance. These liquids contain no specific elements, such as we find in most secretions, but have a chemical composition similar to that of the blood from which they are derived. It would seem very probable, then, at first glance, that such secretions are formed as the products of filtration and diffusion. The plasma of the blood in the capillaries is under greater pressure than the lymph impregnating the tissues, so that we should expect a steady filtration of the plasma through the capillaries into the lymph of the tissues, and, in turn, a transudation of this lymph upon the free surface of membranes, such as the ordinary serous membranes. According to this view the epithelial cells of such a membrane take no active part in the formation of the transudation or secretion, whichever we choose to call it. Since in all secretions, even those in which we have a specific element characterizing the secretion, and undoubtedly formed *de novo* by the metabolic activity of the gland-cells, we have also certain products, the water and salts, which may be considered as derived directly from the blood by the physical processes mentioned, it will be necessary to distinguish in each secretion two kinds of substances—one manufactured by the cells of the gland from nutritive material furnished by the blood, or, more correctly speaking, the lymph; and one derived from the lymph by filtration and diffusion—that is, transudation-substances—whose formation is not dependent upon the life-processes of the gland-cells. Some such distinction is actually made at present by physiologists, as we shall see when describing the secretion of the salivary glands. But the distinction is not usually drawn as sharply as indicated above, for the reason that many facts are known which seem to show that the formation of even the water and salts of secretions is in some way connected with the activity of the secreting cells.

To illustrate the difficulties encountered in explaining transudations by referring them to the physical processes of filtration and diffusion, some recent experiments of Tigerstedt and Santesson[1] may be quoted. These experimenters found that while filtration takes place readily through dead animal membranes, nevertheless, when living membranes were used, such, for instance, as the lung of a frog, and filtration was attempted under the same pressure, with serum or normal salt solution, no filtrate at all was obtained. If the living lung-tissue that allowed no liquid to filter through it was killed by heat, or by any other means, filtration quickly commenced. Similar results were obtained with the frog's intestines and abdominal wall; and if we were justified in applying these results to the other membranes of the body, it would be necessary to explain transudations by something more than simple physical laws. The authors cite many facts to show that even the formation of lymph, which has always been regarded as caused by the filtra-

tion of blood-plasma through the thin walls of the capillaries, is apparently independent of the blood-pressure, in many cases at least; for, if produced by filtration, the amount of lymph obtained ought to increase with increase of blood-pressure. They conclude from their experiments that the transudation of the blood-plasma to form the lymph is caused by the activity of the cells composing the capillary walls, and this conclusion, if correct, will apply *à fortiori* to transudations of the lymph through the basement-membrane and epithelial covering of glandular walls. Investigations like this compel us to be cautious in explaining the simplest phenomenon of the animal body by physical laws obtained from the study of dead matter. It may be convenient to speak of transudations as opposed to secretions proper. The distinction has some basis in the fact that in transudations the chemical constituents are qualitatively the same as those of the blood or lymph from which the transudation is derived, while the secretions proper are characterized by the presence of certain constituents not normally contained in the blood, but manufactured in the glandular cells in consequence of their metabolic processes; nevertheless it would be gratuitous, at present, to assume that in transudations the epithelial cells act simply as a filter or membrane through which certain things pass in consequence of a greater pressure on one side. It is certainly possible that the epithelial cells may take an active part in the production of the water and salts of a secretion, as well as in the formation of mucin or specific ferments. As long as the word transudation has the significance it possesses at present, a division of the secretions into transudations and secretions proper has, perhaps, as little right to acceptance as the old separation into excretions and secretions.

The facts known and the theories maintained, with regard to secretion, can be best presented by a description of the physiology of the salivary glands and the pancreas, from the study of which most of our knowledge on this subject has been obtained. But before passing on to the physiology of these glands it will be well to review briefly the principal theories of secretion held by physiologists from the time of Haller, since the relative importance of the facts which we now possess can be more clearly emphasized by such a comparison. Though Haller is credited with being one of the chief opponents of the old mechanical school of physiologists, the physiology of secretion as given by him is almost entirely mechanical. He divided the secretions into four classes, and held that the substances composing these secretions all pre-existed in the blood, from which they were separated by various mechanical means. The alveoli of the glands were supposed to be formed of "arteries and veins, divided and subdivided," and the arteries were connected directly with the ducts of the glands by pores or canals of varying sizes. This belief in the connection between the arteries and ducts was a deduction from the heroic injections of those days, or what Haller calls "the superlative art of great anatomists," by which wax injections were forced from the arteries into the gland-ducts. The fact that the different secretions, although derived from the same source, the blood, possess marked and constant differences of composition was explained by supposing that the pores or canals connecting the arteries and ducts were of different sizes; none of them were large enough to allow the unchanged blood with its corpuscles to pass through, but some were smaller than others and allowed only the lightest and most volatile particles of the blood to pass, while the larger pores gave passage to the grosser particles. Additional factors in causing the differences in the different secretions were found in the angle, whether acute or a right angle, which the artery supplying the gland made with the main trunk, and also in the difference in velocity of the blood-stream in the secreting arteries, depending on the width of the artery, distance from the heart, etc. Similar mechanical views were held well into the nineteenth century, until the masterly work of Johannes Müller, on the structure and physiology of secreting glands, laid a true foundation for modern views.

Müller proved that no pores of communication exist between the arteries and ducts of the gland; he described the anatomy of the glands and the relations of the blood-vessels to them, and showed that the nature of the secretion was not dependent on the gross structure of the gland, nor on the way in which its vascular supply was obtained. "The nature of the secretion depends solely on the peculiar vital properties of the organic substance which forms the secreting canals," is his final conclusion, and he states his belief that "the variety of secretion is due to the same cause as the variety of the formation and vital properties of organs generally; the only difference being that, in nutrition, the part of the blood which has undergone the peculiar change is incorporated with the organ itself, while in secretion it is eliminated from it."[2] The extensive researches of modern times have added very much to our knowledge of the histology and chemistry of secreting tissues; but, as Heidenhain remarks, if we substitute the term "cells" for "living substance," or "organic substance," the words of Müller just quoted express the conclusion to which modern physiologists have come, and but little can be added to them.

The most important advances made since Müller's work have been connected with the cell-theory of Schwann, and the discovery of the laws of diffusion through membranes by Dutrochet. Schwann's conception of the cellular structure of the animal body was followed by careful histological investigations of the structure of glands as well as of other organs. The glandular epithelium was described, though the physiology of secretion was not at first directly benefited by this discovery. The laws of diffusion of liquids through membranes seemed to promise great things for the physiology of secretion, and investigations upon this basis were eagerly taken up by some of the best physiologists. As a consequence of this, the physical theories of secretion again came to the front, and have since occupied an important position in the explanation of secretory phenomena. Ludwig, in his "Physiology" (vol. ii., 1861), develops in detail the conceptions of filtration and diffusion in their application to the processes of secretion. According to him, the forces concerned in the production of secretions are filtration, diffusion, and also the action of stimulated nerves, though he was careful to say that other forces still might contribute to this result. Ludwig knew, of course, at the time of the publication of his "Physiology," that the organic material found in the secretions of the salivary gland, etc., was not obtained directly from the blood, but was made in the gland itself; but it is important to notice that, by the aid of the simple physical phenomena of diffusion and filtration, he was able to build up a theory of secretion that to a large extent accounted for the specific differences found in the secretion of different glands. The discovery by Ludwig that some of the glands—the submaxillary gland, for example—give a secretion when the nerve-fibres going to them are stimulated, was an extremely important addition to our knowledge of secretion, and has played a large part in recent theories of the physiology of glands. The researches of the same distinguished physiologist proved that the secretion in this case is not owing to simple filtration from the blood, even if the water and salts alone of the secretion are considered; for it was found that in some cases the pressure in the gland might rise to nearly double the mean pressure of the blood in the carotid artery. An equally important observation, also made by Ludwig, was that the temperature of the gland and of its secretion increases during the act of secretion, a fact which would seem to indicate that active chemical changes take place.

At about this same period, also, Claude Bernard found that during stimulation of the nerve going to the submaxillary gland the blood-flow through the gland is greatly increased, suggesting again an increased nutritive activity of the gland in secretion. If Ludwig, at the time his "Physiology" was published, laid too much emphasis on the purely physical factors in secretion, it is nevertheless mainly owing to the important discoveries made by

himself and his pupils that these physical forces have been found to be insufficient. The numerous researches of the last twenty years have shown that, in many of the glands we have true secretory nerves, comparable in their functions to the motor nerves of muscles. Just as stimulation of the nerve of a muscle causes the muscle to enter into functional activity, to contract, so the stimulation of the secretory nerve causes the gland to enter into functional activity, and form its proper secretion. Chemical examination of these secretions has shown that, in some glands at least, the most distinctive constituents of their secretion do not exist at all in the blood, but are formed within the gland.

This dependence of secretion on nervous influences, and the undoubted chemical changes which take place in the gland during its period of activity, have forced us back again to the position held by Müller, that the nature of the secretion depends upon the properties of the living substance which forms the glands. This living substance we now know consists of glandular epithelium cells, and it is to-day the most difficult problem in the study of secretion to understand the properties of these secreting cells. As Müller pointed out, it is only a particular case of the wider problem of nutrition shown by all living cells. A satisfactory theory of secretion must give us some conception of the metabolic changes undergone by the gland-cells at rest and during activity, and the way in which nervous influences affect these changes. We are indebted to no one more than to Heidenhain for what we know at present with regard to the action of the nerves on secretion, and the histological changes shown by the gland cells during rest and activity. His study of the cells of the glands, together with similar work by Kühne, Langley, and others, forms the most important contribution of recent times to this difficult problem. We are far, as yet, from having sufficient data for the construction of a general theory of secretion applicable to all glands, but a large number of facts tending in this direction have been accumulated, especially in the case of the salivary glands and the pancreas. A detailed account of the physiology of secretion in these glands, therefore, will best show the nature and importance of the views now held. The knowledge that has been gained of the physiological processes involved in the secretion of these glands is more complete than for the other glands of the body, though the views presented may be, and are, looked upon as the foundation for a general theory of secretion. But the application of the views derived from the study of these glands to the secretions formed by other glands, is in many cases simply a matter of inference, and lacks any experimental basis.

Salivary Glands.—We can take it for granted that the gross anatomy of these glands is sufficiently well known, and that we may pass at once to a description of their histology, as far as it is necessary to an understanding of their functional activity. Heidenhain distinguishes in the salivary glands two different types of secreting cells, characterized both by the nature of the secretion formed and by the histological appearances of the cells. Glands containing cells of the first type give a thin, watery secretion containing, in addition to the water, only albuminates, salts, and, in some cases, a diastatic ferment. He speaks of them as *albuminous* (or *serous*) *glands*, and examples of this class are found in the parotid gland of man and the mammalia generally, and in the submaxillary gland of the rabbit. Glands of the second type he names *mucous glands;* the secretion which they form is thicker and more mucilaginous, containing mucin as its principal constituent, in addition to a certain amount of salts and albuminates. The submaxillary gland, in most mammalia, and the sublingual belong to this type. The submaxillary gland of man is of a mixed character. Most of the alveoli contain only granular albuminous cells; some contain only mucous cells, and others have partly albuminous and partly mucous cells. The sublingual of man is also a mixed gland, but approaches more nearly the type of mucous glands than the submaxillary.

The alveoli of the albuminous glands consist of a basement membrane, or tunica propria, covered with the glandular epithelial cells. The basement membrane itself is formed of a number of flattened and branched connective-tissue cells, the branches fusing with one another to form a network, while the spaces between the branches are filled up by a structureless membrane or matrix. The gland-cells are of a polygonal or cuboidal shape, and are characterized by their very granular structure. On this account the boundary line between the different cells is seen with some difficulty. Each cell shows a distinct nucleus often of an irregular shape, and a number of dark granules in the body of the cell, which are colored by the different staining reagents, such as borax carmine and Heidenhain's hæmatoxylin. An example of this type of gland is shown in Fig. 3422. The alveoli of the mucous glands have a

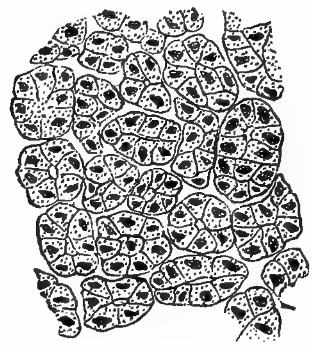


Fig. 3422.—Albuminous Gland (Resting). Parotid of the Dog. (After Heidenhain.)

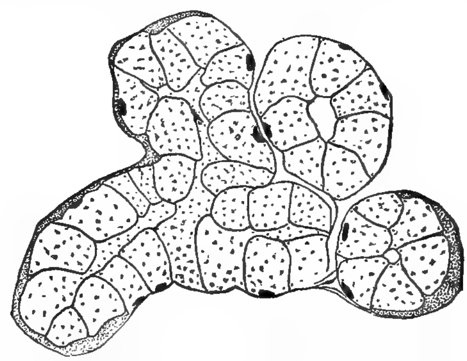


Fig. 3423.—Mucous Gland. Submaxillary of Dog. Resting stage. (From a camera-lucida drawing of a gland stained in Heidenhain's hæmatoxylin.)

basement membrane of the same structure as in the albuminous glands, but the secreting cells upon it are of quite different appearance, as shown in Fig. 3423. They are large, clear, and possess few granules; each has a

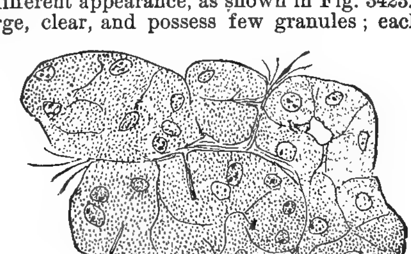


Fig. 3424.—Human Submaxillary Gland. (From a camera-lucida drawing of a gland stained in Heidenhain's hæmatoxylin.)

distinct nucleus which lies toward the base of the cell. The clear substance making up the body of the cell does not stain, and gives the micro-chemical reactions of mucin. In perfectly typical mucous glands there are often

found cells of another character, granular protoplasmic cells, lying between the mucous cells and the basement membrane. These cells are usually spoken of as the *demilune cells of Giannuzzi*, and play an important part in the functional activity of the gland. (See Fig. 3425.)

The secretory ducts in both types of glands show about the same structure. The larger ducts are lined by a

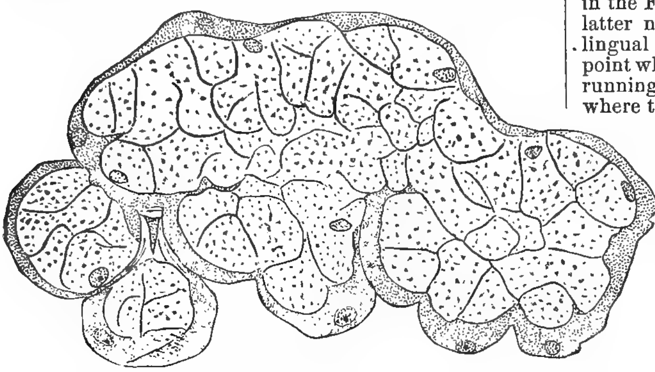


FIG. 3425.—Submaxillary Gland of Cat, showing the Demilune Cells. Camera-lucida drawing.

simple columnar epithelium, which, in all probability, has only a protective function, and cannot be considered as a secreting surface. The smaller ducts leading to the alveoli have also a layer of columnar or cuboidal epithelial cells, which show toward the base, where they sit upon the basement membrane, a striking longitudinal fibrillation. These small ducts are united to the acini by what are known as the "intermediate piece"—ducts of the finest calibre—which in the mucous glands are lined by short cuboidal cells, that, at the junction of the tube with the acinus, pass suddenly into the large, clear, secreting cells of the gland. The cells of the intermediate piece in the albuminous glands are said to be more elongated and spindle-shaped, and project some distance into the alveolus. The salivary glands are supplied with nerve-fibres from the sympathetic and cranial nerves, and histological examination of the gland shows a rich network of nerve-fibres and ganglia between the lobes and acini. Some of these fibres are vasomotor, and are distributed to the blood-vessels of the glands; others are undoubtedly secretory, and in some way connected with the secreting cells. The way in which the secretory fibres end in the cells has not yet been determined satisfactorily. Some years ago Pflüger published several papers in which he described in detail how the nerve-fibres penetrated into the cells of the alveoli and ducts, and the axis-cylinder broke up into fibrils which were lost in the cell. But these results have not been confirmed by later histologists, so that we are not justified in accepting them, although the facts known with regard to the physiology of secretion seem to demand some such connection between the cells and nerve-fibres as that described by Pflüger.

Influence of the Nerves on the Secretion of the Salivary Glands.—In 1851 Ludwig discovered that after continuous stimulation of the chorda tympani nerve going to the submaxillary gland, in the dog, the saliva secreted suffered a change in its chemical composition of such a nature that the percentage of solid constituents, especially of the organic substances, was diminished. Heidenhain afterward took up the same line of experiments, and to his thorough and thoughtful work we owe most of our knowledge on this subject. An account of his experiments may be found in *Pflüger's Archiv für die gesammte Physiologie*, vol. xvii., p. 1, from which the following account is chiefly taken. His experiments were made upon the submaxillary gland of the dog, and the parotid gland of the dog and the rabbit. The submaxillary gland of the dog derives its nerve-fibres from two sources: First, cerebral fibres which originate in the facial nerve, but afterward leave this nerve in the Fallopian canal to join the chorda tympani; this latter nerve, after running for some distance with the lingual branch of the fifth cranial nerve, leaves it at the point where the lingual crosses the duct of the gland, and running along the duct reaches the gland. At the point where the chorda tympani leaves the lingual there is a small ganglion—the submaxillary ganglion. Second, sympathetic fibres which leave the sympathetic trunk above the first cervical ganglion, and pass to the gland along the two branches of the facial artery which supply the gland with blood.

If the chorda tympani is stimulated by weak induction shocks the gland almost immediately begins to secrete, and this secretion, by proper regulation of the stimuli, may be kept up for hours. The secretion obtained in this way is comparatively thin and watery, and contains not more than one or two per cent. of solids when evaporated to dryness. If the sympathetic fibres are stimulated in the same way, quite a different result is obtained. The secretion in this case is relatively small in amount, and flows very slowly. Instead of being thin and clear, like that obtained by stimulating the chorda, it is thick and turbid, and may contain as much as six per cent. of total solids after evaporation to dryness. The results of stimulation of the two sets of fibres show other differences, especially in the circulatory changes in the gland. During stimulation of the chorda the abundant flow of saliva is accompanied by a greatly increased flow of blood through the gland; the whole gland becomes of a reddish hue; the veins passing off from it are distended by the increased flow of blood through them, and, if they are cut, the blood flows from them in a much stronger stream than in the resting gland, of a redder color, and often with a decided pulse. We must suppose, then, that the chorda contains, in addition to secretory fibres belonging directly to the gland, also vaso-dilator fibres passing to its blood-vessels. During stimulation of the sympathetic

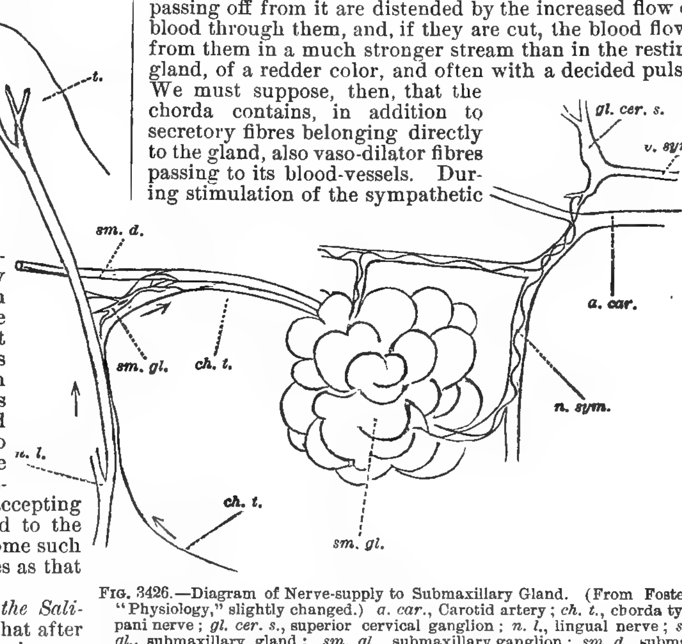


FIG. 3426.—Diagram of Nerve-supply to Submaxillary Gland. (From Foster's "Physiology," slightly changed.) *a. car.*, Carotid artery; *ch. t.*, chorda tympani nerve; *gl. cer. s.*, superior cervical ganglion; *n. l.*, lingual nerve; *sm. gl.*, submaxillary gland; *sm. gl.*, submaxillary ganglion; *sm. d.*, submaxillary duct; *t.*, tongue; *v. sym.*, vago-sympathetic trunk; *n. sym.*, sympathetic branches to the gland.

we get an opposite set of phenomena, the gland becomes pale, and if the veins returning from it are cut the blood flows out in single drops, or ceases altogether. The sympathetic branches, in other words, contain, in addition to secretory fibres proper, also vaso-constrictor fibres going to the blood-vessels.

Influence of the Strength of the Nerve Stimulation upon the Chemical Composition of the Secretion.—If the stimulus applied to the chorda be gradually increased in strength, care being taken not to exhaust the gland, the chemical composition of the secretion is found to change with regard to the relative amounts of the water, the salts, and the organic constituents. The water and salts of the secretion increase with increased strength of stimulus up to a certain maximal limit, although the increase in the two does not run along exactly parallel lines. After the maximal percentage of salts has been reached, further increase in strength of stimulus has no effect, the percentage remaining practically constant, as shown in the accompanying diagram (Fig. 3427).

It is of special importance to notice that these results are obtained from the gland in all cases, no matter what its previous condition was—whether it had been formerly stimulated, or whether it had been in a state of rest. With regard to the organic constituents the results are different. If previous to the stimulation the gland was in a resting condition and unfatigued, then increased strength of stimulation is followed at first by a rise in the percentage of organic constituents; and, indeed, this rise is in the beginning more marked than in the case of the salts. But as the gland becomes more and more fatigued, the relative increase in the organic constituents becomes

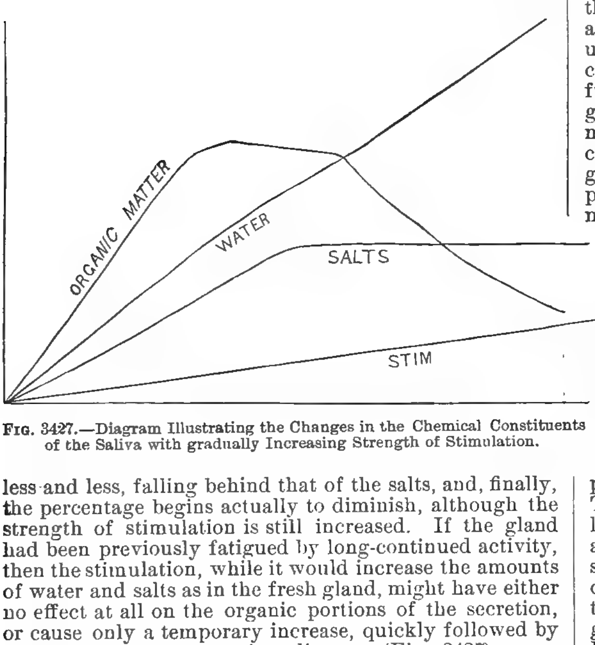


FIG. 3427.—Diagram Illustrating the Changes in the Chemical Constituents of the Saliva with gradually Increasing Strength of Stimulation.

less and less, falling behind that of the salts, and, finally, the percentage begins actually to diminish, although the strength of stimulation is still increased. If the gland had been previously fatigued by long-continued activity, then the stimulation, while it would increase the amounts of water and salts as in the fresh gland, might have either no effect at all on the organic portions of the secretion, or cause only a temporary increase, quickly followed by a fall. The accompanying diagram (Fig. 3427) represents the relative increase in these three components of the secretion, in an unfatigued gland, as the stimulation is made stronger. An examination of the diagram shows that the water and salts, though not increasing in exactly the same ratio, have much in common, whereas the curve of increase of organic constituents runs an entirely independent course. These facts lead us to believe that the conditions determining the secretion of the organic substances are different from those affecting the water and salts, and this view is confirmed by the results of stimulation of the sympathetic fibres. Stimulation of the sympathetic fibres going to the submaxillary gland causes a vaso-constriction of the blood-vessels and a flow of saliva. But the stream of saliva is very different from that obtained by stimulation of the chorda tympani; it is very slow, and the saliva, instead of being clear and watery, is thick and turbid. Chemical analysis of the saliva secreted after stimulation of the sympathetic shows that it contains a much larger percentage of organic matter than that following stimulation of the chorda tympani. This also indicates that the secretion of the organic constituents and that of the water and salts depend upon different conditions. This difference is brought out even more distinctly in Heidenhain's experiments upon the parotid gland.

The parotid gland, like the submaxillary, is supplied by nerve-fibres which are derived from the cerebral nerves, and by sympathetic nerve-fibres. The cerebral fibres have a complicated course; arising first in the glosso-pharyngeal nerve, they leave this trunk by the tympanic branch of the petrous ganglion, or the nerve of Jacobson; from this nerve they branch off in the small petrosal nerve to reach the otic ganglion, and from the otic ganglion they pass to the parotid gland through branches of the auriculo-temporal nerve. Stimulation, then, either of the nerve of Jacobson while in the tympanic cavity, or of the auriculo-temporal nerve, will enable us to determine the effect of these fibres on the parotid secretion. The sympathetic fibres of the parotid reach the gland along the branches of the carotid artery, and may be stimulated while still in the cervical sympathetic.

When the cerebral fibres of the parotid are stimulated, results are obtained similar to those given for the submaxillary gland: the saliva begins to flow at once in large quantities, and is of a clear, watery appearance, while at the same time the circulation through the gland is increased. If the strength of the stimulation is increased, the velocity of the secreted saliva becomes greater, and along with this there is an increase in the quantity of soluble salts, up to a maximal limit. This happens in all cases, whether or not the gland had previously been in functional activity. As in the case of the submaxillary gland, the amount of organic constituents present in this more abundant flow of saliva depends on the previous condition of the gland. If before the stimulation the gland had been secreting actively for some time, then the percentage of organic constituents, instead of increasing, may, on the contrary, begin to fall; while, if the gland had been resting, the organic constituents at first increase, but soon begin to decrease, showing, as in the case of the saliva, that the conditions governing their secretion are different from those under which the water and salts are formed.

This difference is made still more striking by the following observations. If the sympathetic fibres of the parotid gland are stimulated, usually no secretion at all is produced; although the stimulus may be applied for hours, the column of saliva in the cannula placed in the parotid duct remains stationary, provided, of course, the nerve of Jacobson is first cut to prevent any possible reflex stimulation of the gland by this means. Though no secretion flows from the cannula, nevertheless stimulation of the sympathetic has a very important action on the gland, for if shortly afterward, or at the same time, the nerve of Jacobson is stimulated, the saliva obtained differs markedly from that obtained by stimulation of the nerve of Jacobson alone, inasmuch as the organic constituents are greatly increased. In some cases Heidenhain stimulated at the same time the cerebral fibres going to each of the parotid glands, and on one side stimulated simultaneously the sympathetic fibres going to one of the glands; as a result of this the secretion from the latter gland was found to be very much richer in organic constituents. While the organic substances are thus largely increased by stimulation of the sympathetic fibres—the secretion sometimes containing tenfold the amount of organic matter—nevertheless the percentage of salts in the secretion is not affected by the action of the sympathetic fibres. Very weighty evidence is thus obtained showing that the nerve-fibres which cause the formation of the organic portion of the secretion are distinct from those which bring about the separation of the water and salts. Heidenhain's theory to account for these facts is as follows:

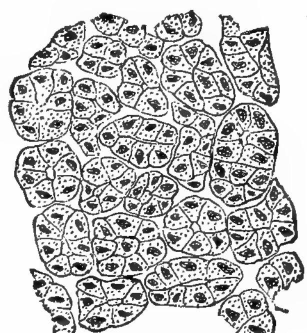
Theory of Secretory and Trophic Nerve-fibres.—The fact that the increased flow of saliva in both the submaxillary and parotid glands of the dog, when the cerebral fibres are stimulated, is accompanied by active vaso-dilatation of the blood-vessels of the gland, while the diminished secretion in both cases from stimulation of the sympa-

thetic fibres is associated with strong vaso-constriction of the blood-vessels of the gland, would lead one naturally to the supposition that the amount of secretion in each case was dependent on the quantity of blood flowing through the organ. On the hypothesis that the secretion is the result of filtration and diffusion from the blood, the increased flow in one instance, and the diminished flow in the other, would seem to find a sufficient explanation in the changes in the blood-supply. But we possess very complete proofs that this supposition is erroneous, and that the secretion is independent of any increase or diminution in the quantity of blood flowing through the gland.

Ludwig first showed that if a mercury manometer is connected with the duct of the submaxillary gland, and the chorda tympani is then stimulated for a certain time, the pressure in the ducts of the gland, as shown by the manometer, may become much greater than the blood-pressure of the animal, the excess of pressure in the gland being in some cases as much as 100 mm. of mercury. This pressure in the ducts is, of course, continued backward into the alveoli, and it is not possible to conceive, under these circumstances, that the secretion is a filtration product from the blood and lymph of the gland, since the filtration stream always proceeds from a place of higher to one of lower pressure. So it has been observed that if the blood-supply is completely shut off from the gland by clamping the arteries, stimulation of the chorda will still excite a secretion for a short time. The neatest and most conclusive experiments that have been brought forward to demonstrate that the flow of saliva is independent of the changes in the quantity or pressure of the blood, are those obtained from the action of atropine and the hydrochlorate of quinine upon the gland. Kenchel (Dorpat, 1868, "Das Atropin und die Hemmungsnerven") showed that atropine injected into the blood, or directly into the gland, completely prevents the secretory action of the chorda tympani; nevertheless stimulation of the chorda[3] causes vaso-dilatation of the arteries of the gland, just as it does without the previous administration of atropine. That is, the atropine paralyzes the secretory fibres of the chorda, while it does not affect the vaso-motor fibres, and the gland in this case will not secrete a drop, although the quantity of blood flowing through it is largely increased, and the pressure in the capillaries is much greater than in the resting gland. The action of quinine is even more conclusive. Heidenhain found (Hermann's "Handbuch der Physiologie," vol. v., p. 45) that if he mixed 10 c.c. of saliva, secreted under stimulation of the chorda tympani, with 2 c.c. of a saturated solution of hydrochlorate of quinine, diluted this neutral mixture to 20 c.c., and then injected a few cubic centimetres into the duct of the salivary gland, he got a greatly increased flow of blood in the gland, but no trace of a secretion. Nevertheless, if the chorda was stimulated a rich flow of saliva was obtained. In this experiment the secretory fibres were not paralyzed, but remained perfectly irritable, while the strong vaso-dilatation caused by the quinine, without simultaneous stimulation of the secretory fibres, was powerless to produce any secretion. From these experiments we are forced to conclude that, as far as the submaxillary gland is concerned at least, the secretion is not caused by a simple increase in the quantity and pressure of the blood in the gland capillaries. On the contrary, we must recognize the existence of true secretory fibres, which exert their action upon the gland-cells directly, and not indirectly by alterations of the blood-stream.

From the experiments upon the parotid and submaxillary glands given above, Heidenhain concludes that we can divide these secretory fibres into two classes, one of which he calls trophic fibres and the other secretory fibres; stimulation of the latter causes the secretion of water and salts, while stimulation of the trophic fibres causes the formation of soluble organic products in the protoplasm of the gland-cells, and these products are then dissolved in the water of the secretion. Upon this hypothesis we can explain the action of the secretory nerves upon the parotid and submaxillary glands in the following way: The sympathetic nerve-branches going to the parotid gland (of the dog) contain only trophic fibres, so that stimulation of this nerve, while it causes important changes in the gland, and the formation of the organic constituents of the secretion, gives no perceptible secretion, because there is no stream of water to dissolve and carry out these products. The nerve of Jacobson, on the other hand, contains mainly secretory fibres, and but few trophic fibres, so that stimulation of this nerve will give an abundant flow of saliva, which, however, will be poor in organic material. In the same way, the chorda-tympani nerve may be considered as composed mainly of secretory fibres, while the sympathetic branches to the submaxillary contain many trophic fibres, together with a sufficient number of secretory fibres to give a slow flow of saliva, rich in organic products, when these nerves are stimulated. Granting that we have two such classes of fibres, how can we conceive their action to take place? In what way do the secretory fibres bring about the secretion of water and salts, and the trophic fibres cause the formation of the organic material of the secretion? These are difficult questions to answer, and it is impossible, with the knowledge we now possess, to give any really satisfactory explanation of these phenomena. The action of the trophic fibres is perhaps better understood, so that we may consider them first. Our ideas of the way in which the trophic fibres act rest partly upon the chemical changes caused by their stimulation, and partly upon the simultaneous morphological changes which can be detected in the gland. The former have been mentioned already; the changes in the histological appearance of the gland have been described by Heidenhain from preparations of the hardened gland, and by Langley from observations upon the living gland. The most important results may be briefly stated as follows:

Histological Changes in the Active Gland as Evidence for the Existence of Trophic Fibres.—If a resting albuminous gland—the parotid of the dog, for instance—is har-



[Fig. 3422.—Albuminous Gland (Resting). Parotid of the Dog. (After Heidenhain.)]

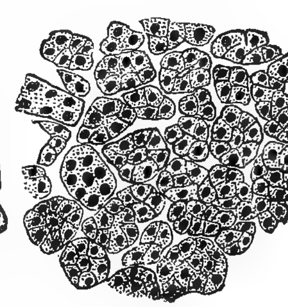


Fig. 3423.—Albuminous Gland, after Strong Secretion. Parotid of the Dog. (After Heidenhain.)

dened in alcohol and then stained in carmine, or, better still, if stained in Heidenhain's hæmatoxylin, we see that the cells are more or less compactly filled with fine granules, which receive a stain from the hæmatoxylin, and are embedded in a clear ground-substance which does not stain. The nucleus of each cell, according to Heidenhain, is small and of irregular outline. If, now, the nerve of Jacobson is stimulated in another gland, and the gland is then hardened in alcohol and stained, very little, if any change will be observed in it, unless the stimulation has been very strong and continued for many hours. But if, at the same time, the sympathetic fibres had been stimulated also for a comparatively short time, very marked changes will be noticed. The cells are distinctly smaller, the nucleus becomes rounder and shows nucleoli, while the cells present a more granular appearance, owing to the diminution in the amount of clear ground-substance contained in them. The diminution in the size of the cells, and the different relative quantities of clear substance and granules, show that the organic ma-

terial of the secretion, which, as we have seen in the case of the parotid, is so largely increased by stimulation of the trophic fibres in the sympathetic, must have been derived from the substance of the cells. In some way the action of these fibres causes metabolic changes in the cell protoplasm and the formation of the organic portion of the secretion. If the gland is again allowed to rest, the proportion of clear substance to granular material increases, and the cells become larger. Heidenhain concludes, therefore, that the clear substance is the material from which the organic products of the secretion are directly formed, and that during secretory activity it is converted into these products and washed out of the cell by the stream of secreted fluids; while in periods of rest the protoplasmic substance of the cell is first regenerated from the food-material given by the blood, and then converted into this clear ground-substance; the latter may be looked upon, not as the organic material of the secretion, but as the substance from which this material is formed, in consequence of metabolic changes set up in it at the moment of secretion by the action of the trophic nerve-fibres.

Langley's experiments upon the changes during secretion in the albuminous glands[4] yielded him somewhat different results. His experiments were made upon the fresh living gland, either by cutting out bits of the gland during rest and activity, or, in the case of the parotid of the rabbit, a portion of the gland, while still in the body, was placed under the microscope, and its appearance observed while the blood was circulating freely through it. He found that, when the animal was in a fasting condition, the cells of these glands had a granular appearance throughout their substance, the outlines of the different cells constituting an alveolus being faintly marked by light lines. When, however, the gland was made to secrete, by giving the animal food, by injecting pilocarpin, or by stimulating the sympathetic nerve-fibres going to it, the granules began to disappear from the outer borders of the cells—that is, from the border turned toward the basement membrane—so that each cell now showed an outer clear border and an inner granular portion. After prolonged secretion very few granules were left in the cell, and these formed a thin layer at its inner portion bordering upon the lumen, and stretched outward for a greater or less distance along the sides of the cells. During secretion, also, the cells separated slightly from one another at the lumen, and this, with a distinct diminution in the size of the individual cells, caused the lumen in each alveolus to become more manifest. He found that these appearances could not be preserved by hardening the gland in alcohol or osmic acid, so that probably Heidenhain's observations on the hardened gland do not accurately represent the changes that take place in the living gland.

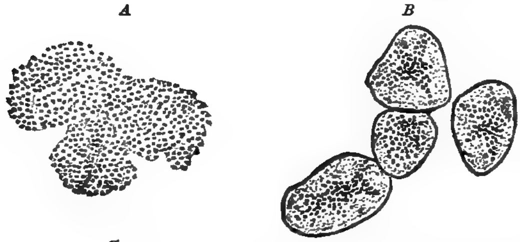
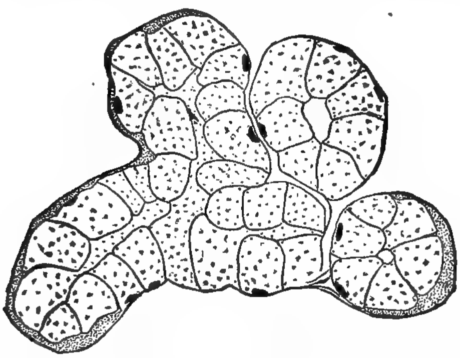


Fig. 3429.—From Langley's paper. *A*, Cells of parotid gland of rabbit in resting condition; *B* and *C*, after strong secretion, showing the disappearance of the granules.

From these results we must believe that in the albuminous glands, as we shall find to be the case in the pancreas, the granules represent the substance from which the organic constituents, and especially its specific ferment, are formed, and that stimulation of the trophic nerves causes the expulsion of these granules. It is not believed that the granules are forced out as such in the secretion-stream, but that they represent the material from which the organic products of the secretion are formed, at the moment of secretion, under the influence of the trophic nerves. Following the analogy of the pancreas, this preliminary material may be spoken of as a zymogen. It is formed from the protoplasmic contents of the cells, and deposited in the form of granules, which, in turn, are dissolved and changed into ptyalin and the organic products of the secretion during the period of glandular activity. We know nothing of the chemical reactions that occur in this process; but from analogy with what we know to take place when other tissues—muscles, for instance—enter into functional activity, it is most probable that these chemical changes are of the nature of destructive metabolisms or katabolisms. The term trophic, which Heidenhain has used to characterize the nerve-fibres causing these changes, is, as Gaskell has pointed out, somewhat unfortunate. Trophic or nutritive nerves are usually understood to be those whose action leads to a constructive metabolism or anabolism in the tissue to which they are distributed. A better designation for these gland-nerves, then, would be that suggested by Gaskell, viz., katabolic nerves. However, Heidenhain believes that the nerves in question, when stimulated, cause changes in the gland-cells of a twofold character. On one hand, the zymogen—the substance from which the ptyalin and organic products in the secretion are directly formed, and which in this case is stored up in the cells in the form of granules—undergoes katabolic changes, with the production of the characteristic elements of the secretion; while, on the other hand, active constructive metabolisms are in progress, which result in the formation of new material in the cell from the food furnished by the lymph. This new material can be recognized in the living cell as the clear non-granular substance, which in the active gland makes a distinct zone at the base of the cell. This, in turn, is changed into the granular material, but whether this change is katabolic or anabolic cannot be determined with certainty. We must recognize that these two processes go on simultaneously in the cell, and the diminution in size of the cell during activity is from the excess of the destructive over the constructive changes, while the growth of the cell during the period of rest is owing to the greater constructive metabolisms. If these processes all result from the action of the gland-nerves, then these nerves are, in part at least, truly trophic or anabolic; but the change which we know most definitely to be the result of their influence, the final change from the zymogen to the organic material found in the secretion, is most probably of a katabolic nature, and Gaskell's term would seem, therefore, to be the most appropriate.

In presenting the theories of the action of the trophic fibres, the phenomena shown by the albuminous or serous glands have alone been considered, but we have equally strong evidence that similar changes occur in the mucous glands. In some respects, indeed, the changes in these glands are more decided, and, fortunately, we have good observations upon both the hardened and the fresh gland in its different conditions of rest and activity. Most of our information is derived from Heidenhain's and Lavdovsky's work upon the hardened glands. According to their descriptions, the mucous cells of the alveoli in the resting gland are large, clear, with flattened nuclei well toward the base of the cells. The demilune cells of Gianuzzi, placed between the basement membrane and the mucous cells, are smaller and of a granular, protoplasmic nature. The clear substance of the mucous cells has all the micro-chemical reactions of mucigen, and seems to be undoubtedly the substance from which the mucus of the secretion is directly formed. When the gland becomes active, from stimulation of the nerve, for instance, the nuclei of the mucous cells become more spherical, show distinct nuclei, and advance more toward the middle of the cells. The cells meanwhile become smaller, because of the transformation of

the mucigen into mucus and its elimination from the cells. If the stimulation is strong and continued for a long time, more important changes take place. According to Heidenhain, the mucous cells break down completely, and are carried off in the secretion, while the demilune, or border cells, grow and form new mucus-secreting cells similar to those destroyed. Such results are obtained, of course, only from excessive artificial stimulation, but Heidenhain believes that this represents a normal physiological process. The individual mucous cells may continue for a time to secrete mucus, and then be regenerated by the formation, first, of protoplasm from the food of the lymph, and the transformation of this into mucigen, but sooner or later the cell is destroyed, and its place is supplied by one of the demilune cells. That we do not see any evidence of this in sections of mucous glands, not submitted to artificial stimulation, is owing to the fact that the change only affects individual cells, and would necessarily be inconspicuous under normal



[FIG. 3423.—Mucous Gland. Submaxillary of Dog. Resting stage. (From a camera-lucida drawing of a gland stained in Heidenhain's hæmatoxylin.)]

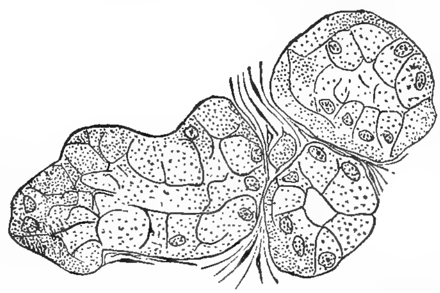


FIG. 3430.—Submaxillary Gland of Dog after eight hours' Stimulation of the Chorda Tympani. (From a camera-lucida drawing.)

conditions, since probably only a few cells in the gland would be undergoing this change at the same time.

More recently Langley [6] has made experiments upon the fresh gland with regard to its histological appearance during rest and activity, using the submaxillary and the sublingual glands of the dog. He finds that in the resting gland, when treated with dilute solutions of neutral or alkaline salts, he could detect, along with the hyaline material in the cells, a number of granules, both inclosed in a network stretching throughout the cell. The granules extend through the cell, and during secretion both the hyaline substance and the granules are "turned out of the cells; after prolonged secretion the cells consist of an outer zone, chiefly of freshly formed substance, and of an inner zone of network, hyaline substance, and granules." Langley does not agree with Heidenhain and Lavdovský in believing that the mucous cells disintegrate during secretion and are replaced by the demilunes. On the contrary, he thinks that the demilunes are secreting cells of a different nature, belonging to the albuminous type, and that the mucous cells, after their period of activity is over, grow again to their original size in a way closely comparable to that described as occurring in the parotid gland and the pancreas.

Action of Secretory Fibres.—The term secretory fibres is applied here in a restricted sense to those fibres whose stimulation excites a secretion of water and salts. This name also seems somewhat unfortunate, as it would be more convenient to speak of all the glandular nerve-fibres as secretory, as, indeed, is usually done. It has been suggested that transudatory fibres would be a better designation, and it would certainly be a more convenient one, inasmuch as it would enable us to speak of two different things by different names. The term, however, is not entirely free from objection. By transudations we are accustomed to understand fluids formed by filtration or diffusion through membranes in the body. It is more than doubtful whether the action of the fibres in question can be considered of this character—that is, as simply increasing or permitting the filtration and diffusion of water and salts from the lymph through the basement-membrane and cells into the lumen of the alveolus. As was shown in the beginning of this article, there seems to be an accumulation of evidence forcing us to the belief that transudation through living membranes is quite a different thing from filtration or diffusion through dead membranes. If we use the word transudatory simply to indicate the fact of the production of water and salts in the secretion, without any reference to the manner in which they are formed, the term will be a useful one; but inasmuch as this conception of filtration and diffusion is generally attached to the word, it will be better for us to use the non-committal term secretory, in the sense in which it is employed by Heidenhain.

How the water of the secretions is formed has always been a difficult question to decide. Quite a number of theories have been proposed from time to time, but none of them are really satisfactory, and on this point, as on many others in physiology, we must await future histological and physiological researches. We know that at bottom the stream of water in secretion is caused by chemical and physical agencies, but what the nature of these phenomena is remains to be discovered. We have abundant proof, part of which has already been given, that it is not a case of simple filtration or diffusion from the blood in the capillaries; we know that changes in the pressure in the capillaries have no direct effect on the quantity of water in the secretion. Gianuzzi divided the process of water-secretion into two different and independent stages: First, the filtration of the water through the blood-capillaries into the lymph-spaces; second, the transference of this water from the lymph to the lumen of the alveolus through the activity of the cells. Heidenhain has shown that this hypothesis, the first part of it at least, is contradicted by facts, and it introduces a new difficulty in the way of understanding how these two processes are regulated with respect to each other. Another theory, suggested by Hering, is that —in the submaxillary gland, for instance—stimulation of the secretory nerves causes the formation within the cells of a colloidal substance, mucin, which has a great attraction for water, and that, as a result of the imbibition-power of this mucin, water is carried into the cells, and there forms with the mucin a solution which makes the secretion. If this theory were correct, then those glands which contain the most mucin ought to show the most active secretion. As a matter of fact, this is not the case—the sublingual is richer in mucin than the submaxillary, but the secretion-stream in the former is much less rapid than it is in the latter; so also the organic substances in the parotid saliva may sink to a very small percentage, and yet the secretion may be very active.

Heidenhain's own theory to account for the production of the water as the result of nerve-stimulation is also far from conclusive. He starts from the fundamental fact that no more water leaves the blood-capillaries than appears afterward in the secretion—that is, no matter how long the secretion continues, the gland is never œdematous, nor is the velocity of the lymph in the lymphatics of the gland increased. This being the case, we must suppose that the water-stream is regulated by the secretion—that is, by the activity of the cells of the gland. If, now, we conceive that the substance of these cells, or some constituent of them, has an attraction for water, then while the gland is in the resting state water will be absorbed first from the basement-membrane;

this membrane makes good its loss by subtracting water from the lymph of the tissue, and this, finally, from the blood of the capillaries. The water in the cells increases, and its tension becomes greater, until, finally, the endosmotic power of the cell-substance is held in equilibrium, and the diffusion-stream between the blood in the capillaries and the cells comes to a stand-still. The water held in the substance of the cells cannot escape into the lumen of the alveolus, which would be the natural path for it to take, since there the water is under little or no pressure, because the border of the cell-protoplasm is so constructed as to offer a great resistance to filtration. So the water may be held in the cell under great tension, and yet not be able to filter through this limiting layer into the lumen. The action of the nerves consists in so changing the structure of this resisting layer that it may offer little resistance to filtration, and the water of the cell then filters out into the ducts; its own endosmotic power, no longer held in equilibrium, again draws water from the lymph, etc., and a filtration-stream is started, the moving force of which is this endosmotic power of the cell-substance. In what way the nerves cause a change in the nature of the resisting layer of the cell can only be a matter of speculation. The author of the theory thinks that there is a molecular change or rearrangement in its structure, of such a character that it no longer offers a resistance to the passage of water from a point of high pressure within the cell to one of lower pressure outside of the cell. It is possible, also, that active contractions of the cell-substance may facilitate the secretion of liquid. The whole theory goes far beyond the facts which are known; but it is, perhaps, the best that has been offered, and may be adopted provisionally until future researches give us more data to speculate upon.

Heidenhain says little about the secretion of salts independently of the water in which they are dissolved. Presumably, on his theory, the salts are carried directly in the diffusion-stream, passing from the blood of the capillaries to the cells of the alveoli, and depend no more for their secretion upon metabolisms in the cells than the water does. In accordance with this view, Heidenhain found that the maximum amount of inorganic salts in the submaxillary saliva lay between 0.5 and 0.6 per cent., or, according to the later experiments of Werther, may reach 0.77 per cent.; increased velocity of the secretion-stream beyond this point caused no increase in the percentage of salts. This percentage of salts is still below that of the blood, and calls for no especial secretory activity of the cell to explain its production. In other glands of the body, however, we meet with what seems to be a true secretion of salts—that is, the salts cannot be considered as filtering or diffusing through the gland-cells with the stream of water, but exist in such quantities that they must have been collected from the blood by the secreting cells in some way, and are the direct products of the metabolic activity of these cells. In the mammary gland, for instance, Bunge[6] finds that the salts of the milk not only differ widely in percentage-value from the same salts in the blood, from which they are ultimately derived, but exist in the same percentage by weight as in the ash of the sucking animal for whose food the milk is intended—that is, the epithelial cells pick out from the blood certain salts in the quantities needed for the growth of the young animal. For the proof of this interesting statement Bunge submits the following table of analyses:

100 parts of ash contain:	Sucking animal. Rabbit.	Sucking animal. Dog.	Sucking animal. Cat.	Dog's milk.	Dog's blood.	Dog's serum.
K_2O	10.8	8.5	10.1	10.7	3.1	2.4
Na_2O	6.0	8.2	8.3	6.1	45.6	52.1
CaO	35.0	35.8	34.1	34.4	0.9	2.1
MgO	2.2	1.6	1.5	1.5	0.4	0.5
Fe_2O_3	0.23	0.34	0.24	0.14	9.4	0.12
P_2O_5	41.9	39.8	40.2	37.5	13.2	5.9
Cl_2	4.9	7.3	7.1	12.4	35.6	47.6

There can be no question of simple diffusion and filtration in this case. While the blood of the mother contains in its ash less than one per cent. of CaO, the milk holds over thirty-four per cent., and, on the other hand, the blood contains a large percentage of Na_2O and Cl, while the ash of the milk contains very much less.

Similar results have been obtained from the kidney by Munk.[7] This observer experimented upon kidneys of dogs taken from the body and kept alive by an artificial circulation of defibrinated blood, usually diluted with one-half to one volume of water or normal salt solution. Under these conditions the kidney continued to secrete urine steadily, and the characteristic salts of the secretion always existed in a higher percentage in the secretion than in the blood which was circulating through the gland. The NaCl, for instance, was found without exception to be greater in the secretion than in the blood, the excess varying between eighteen and sixty-seven per cent. Even when by addition of NaCl to the circulating blood the percentage of this salt was raised to 2.28, the weight of NaCl found in the secretion was always from twelve to sixty per cent. higher. The same results were obtained with Na_2SO_4 and Na_2HPO_4, and here, again, the secretion of the salts is undoubtedly connected with the activity of the secreting cells, and is not a passive phenomenon. Munk's success in getting a true secretion of urine from a kidney with artificial circulation is opposed to the experience of other observers, and his results need corroboration before they can be fully accepted.

Stricker and Spina have advocated a different theory of secretion, founded upon some observations made upon the simple racemose glands contained in the skin of the frog.[8] In these simple glands the lining epithelium forms a more or less flattened layer upon the alveolar wall, leaving a relatively large lumen. When the gland is stimulated by electricity, either directly or through nerves, two things happen. In the first place, the whole gland becomes smaller, from a contraction of the external surface, and, secondly, the cells of the alveolus dilate and completely close up the lumen. After the stimulation has ceased, the cells and gland return again to their former condition. As far as the first of these phenomena is concerned, it is probably owing to the contraction of muscular elements in the periphery of the gland. The enlargement of the gland-cells that follows stimulation may be explained either as an active dilatation, or as a passive dilatation from the imbibition of water. The authors hold to the first of these views; they see no reason why nerve-stimulation should not lead to an active dilatation of the cells as well as to a contraction, and believe that the object of the dilatation is twofold. On the one hand, by obliterating the lumen the cells drive out the secretion which was standing in it, and, on the other, their enlargement creates a negative pressure within the cells, in consequence of which water is drawn into them from the surrounding lymph. When the stimulation ceases the cells return to their normal size and squeeze out this water into the lumen. According to this theory the cells act both as a mechanical force-pump and as a suction-pump, drawing the water into themselves, and again forcing it out into the duct. Stricker and Spina have attempted to apply this theory to similar glands—the salivary glands, for instance—but the attempt is hardly worthy of serious consideration. As Heidenhain says, the enlargement of the cells in these glands during secretion, which undoubtedly takes place, is in reality a secondary phenomenon; the stream of water which results from the stimulation causing changes in the cells is the primary phenomenon, and the cells swell up from imbibition of this water. Why stimulation of the nerves should set up a secretion-stream through the gland is the same problem that we have discussed already with reference to the salivary glands, and Heidenhain's hypothesis applies as well in one case as in the other.

Action of Atropine and Pilocarpine on the Salivary Glands.—The action of a number of different poisons on the salivary secretion has been determined more or less

completely. Of these poisons, atropine and pilocarpine, from their decided and antagonistic effects, have always been regarded with peculiar interest. It has long been known that when atropine in minimal doses is injected either into the blood or directly into the gland through its duct, the secretion of the gland very quickly stops, and in the submaxillary gland, upon which most of the experiments have been made, stimulation of the chorda no longer has any effect upon the gland-secretion, although the dilatation of the blood-vessels follows as in the unpoisoned gland. This action of the atropine is not exerted upon the nerve-centres in the cerebro-spinal system, but directly upon the glands. The same effects may be obtained when all nervous connections between the glands and the nerve-centres are severed. The atropine must act either upon the secreting cells directly, or else upon the termination of the nerves in the gland. The second of these views seems to be the probable one, for the reason that when atropine is injected into the blood of a dog the chorda-fibres going to the submaxillary gland are completely paralyzed—no amount of stimulation will cause them to excite a secretion. But even very strong doses will not paralyze the action of the sympathetic fibres of the same gland. Hence the gland-cells themselves must be capable of functional activity. What the atropine has done is to prevent the action of the chorda-impulses on these cells. The connection between the nerve-fibres and gland-cells is unknown, and it remains an open question whether the atropine affects this connection, or possibly acts upon the local centres, small ganglia, which exist in the substance of the gland, and with which, presumably, the chorda-fibres are first connected before passing to the secreting cells. The action of pilocarpine is of the opposite kind. Very small doses (0.001 Gm.), injected into the blood, cause an active secretion of the gland (submaxillary), a secretion which may be increased by simultaneous stimulation of the chorda-fibres. If, however, the dose of pilocarpine is too strong, the gland is paralyzed, as in the case of atropine-poisoning.

Most of our knowledge of the action of these drugs is derived from Langley's work.[9] With regard to their antagonistic action, he states that they have an imperfect mutual antagonism. As long as the dose of pilocarpine is sufficiently small to cause secretion of the gland, the antagonism of atropine for it is perfect—that is, the secretion of the gland can be stopped by injection of atropine. The antagonism of pilocarpine for atropine, however, is less perfect, and is more complete the smaller the dose of atropine—that is, the paralyzing action of the atropine, if the dose is not too great, may be removed by injection of pilocarpine. While the atropine may be regarded as acting upon the peripheral nerve-endings in the gland in such a way as to paralyze them, the pilocarpine in small doses may be supposed to stimulate these nerve-endings, and in larger doses to paralyze them. These facts give us but little aid in understanding the physiological mechanism of secretion, though any theory that is proposed must take them into consideration.

The Secretion-centre.—The salivary glands in the normal relations of the body are set into action, not by direct stimulation of the secretory nerves supplied to them, but reflexly from stimulation of sensory nerves of the tongue, of the buccal cavity, of the alimentary canal in general, etc. The position of the secretory centre through which these reflexes are made has been placed in the medulla, at about the nuclei of origin of the facial and glosso-pharyngeal nerves. Bernard attempted to show that the little submaxillary ganglion placed in the angle between the lingual and chorda-tympani nerves might serve as a reflex centre for stimulation of the endings of the lingual in the tongue. Experiments made by other observers have discredited this theory, and we cannot at present state what the function of this ganglion is with reference to the submaxillary gland. The secretory centre in the medulla can be excited by stimulation of the sciatic or the splanchnic nerve, and can also be stimulated directly by mechanical or electrical means. In strong dyspnœa this centre is usually thrown into action by the stimulating action of the venous blood in the medulla. The secretory centre may also be stimulated by impulses descending from the higher centres in the brain. As is well known, the mere thought of pleasant food may cause a reflex secretion of saliva. On the other hand, the action of this centre may be inhibited either by afferent impulses from various nerves of the body, or by impulses descending from higher centres in the brain. The well-known fact that terror, anxiety, etc., frequently stop the flow of saliva is sufficient proof of this latter statement.

Paralytic Secretion.—Claude Bernard discovered, in 1864, that if the chorda-tympani fibres of the submaxillary glands are cut, the gland ceases to secrete, because the efferent path from the secretory centre is now cut off. Nevertheless, from one to three days after the section of the nerve a slow secretion begins in the gland, and keeps up continuously for several weeks. As a final result of the section, the gland undergoes complete atrophy unless the chorda-fibres again grow out. The cause of this paralytic secretion is very obscure. Heidenhain thought that it was owing, perhaps, to the stagnation of saliva in the ducts, certain products being formed which stimulated the gland. Langley has recently studied the subject with more success than other observers.[10] He has both added new facts to those already known with regard to the results of this section, and has suggested a plausible theory of the cause of the paralytic secretion. Section of the chorda tympani in the cat, according to Langley, is followed by a continuous secretion of watery saliva from the submaxillary gland on both the cut and the uncut side, that on the cut side being the more abundant. The secretion of the gland on the side on which the nerve was cut he calls the paralytic secretion, and that from the gland on the other side, the antiparalytic or antilytic secretion. The primary cause of these secretions he considers to be an increase in the irritability of the cells of the secretory centre. When the chorda on one side is cut, the central secretory nerve-cells become more irritable, and finally the blood flowing through the centre, which is normally somewhat venous, but not enough so to stimulate the centre, becomes now a sufficient stimulus to this more irritable centre, and the impulses pass to the gland on the cut side through the sympathetic fibres which remain uncut, thus exciting the paralytic secretion; while on the other side the impulses descend through both the chorda and the sympathetic, causing the antilytic secretion. Confirmatory of this view he finds that the paralytic secretion may be stopped in its first stages by section of the sympathetic fibres of the same side. In later stages, however, section of the sympathetic fibres, while it may slow the secretion, will not stop it altogether. Langley explains this by supposing that now the local centres in the gland itself have become affected, that is, become more irritable, and are being stimulated continually by the blood flowing through the gland, so that it is possible to get a paralytic secretion from the gland after all nervous connection with the medullary centre is cut off; the secretion in this case would probably take a longer time to develop, as the local centres undergo this change in irritability more slowly than the general centre in the medulla. As a confirmation of this view, Langley points out that in the sweat-glands, in which no peripheral nerve-cells, local centres, are known to exist, no paralytic secretion can be obtained when the nerves of the glands are cut; while in the salivary glands and the pancreas, in which these peripheral nerve-cells have been found, a paralytic secretion is obtained when all the nerves supplying the gland are cut. This theory seems to meet all the facts in the case, and is certainly a great advance on any hitherto offered, though it is somewhat difficult to see why section of the chorda should be attended by an increase in irritability of the central nerve-cells of the medulla.

Secretion in the Pancreas.—In some respects the study of the process of secretion, as exhibited in the pancreas, has been of more service in throwing light upon the phenomena of secretion in general than the study of the salivary gland. This is especially true with respect to the histological changes undergone by the cells during

secretion. Observations upon the hardened gland, in different stages of activity, by Heidenhain, and confirmatory experiments upon the living pancreas of the rabbit, by Kühne and Lea, have given us a pretty clear conception of the mechanism of the secretion of the organic constituents. In other respects, however, the work upon the pancreas has been less successful. Little or nothing is known of the effect of direct nerve stimulation upon the character of the pancreatic secretion, so that the evidence for the presence of different kinds of secretory nerves in this gland is not so direct as in those already described. An account of the physiology of secretion in the pancreas will add, then, but little to the data already given, as far as any general theory of secretion is concerned. But it will serve to show that in many points the process exhibits a fundamental similarity in the two sets of glands, giving us some hope that certain general statements with regard to gland activity may yet be formulated. From what has been said of salivary secretion it is very evident that our knowledge of the real nature of the process is very fragmentary and insufficient, and this is even more conspicuous in the case of the pancreas. The theories in the one case, as far as they have been developed, apply fairly well in the other; but in neither case are the facts sufficient for the construction of a theory of secretion that does not force us to use hypotheses for the truth of which there is little positive proof. Glands so similar in structure as the pancreas and salivary glands must function in essentially the same way, and it seems allowable to supplement the facts known with regard to one by the results obtained, under more favorable conditions, from experiments upon the other. What we have to say about pancreatic secretion, then, will be made as brief as possible, since the general deductions that might be made from its study alone have already been presented in speaking of the salivary glands.

The pancreatic secretion, as obtained from a temporary fistula in the duct of a dog, is a clear, thick, sticky liquid that coagulates in the cold, and shows an alkaline reaction. It contains a large percentage of organic material, which appears to consist chiefly of albuminous bodies, alkali albuminate, and the usual salts, among which the sodium salts are especially abundant. Owing to its large amount of albuminous material the secretion gives a strong precipitate or coagulum when heated. What especially characterizes the secretion, however, is the presence of at least three unformed ferments, or enzymes, which have the power of causing digestive changes in the three chief classes of alimentary principles. These three enzymes are, (1) A diastatic ferment capable of converting starch into sugar; (2) a ferment capable of converting albumins into peptones and amido-acids; (3) a ferment capable of splitting neutral fat into glycerine and the corresponding fatty acid. The physiological action of these ferments does not interest us in this connection; we are concerned only with the way in which they are formed within the cells of the gland, together with the other products of secretion, and with the mechanism by which they are forced out of the cells into the secretory ducts. In cases of permanent pancreatic fistula, where the secretion has been long continued, its characters differ in degree from those given above; the secretion becomes much thinner, and the percentage of solid constituents may sink to a very low level, one or two per cent., while in the fresh gland it may be nine to ten per cent. So all gradations may be obtained according to the condition of the gland. It is evident that the chemical constitution of this secretion places the gland in the albuminous type, and the morphological changes in its structure during rest and activity also suggest strongly the appearances found in salivary glands of this type, *e.g.*, the parotid.

The secretion of pancreatic juice in the dog is not continuous, but intermittent. After the reception of food and the commencement of gastric digestion the pancreatic juice begins to flow out of the duct into the intestine, and continues to be secreted with varying velocity for several hours. By making a pancreatic fistula, and measuring directly the amount of pancreatic secretion that flowed from it, Bernstein,[11] and afterward Heidenhain,[12] have been able to determine the variations in the secretion in the hours following digestion. The curves given by the two investigators agree very well, and the general result, as stated by Heidenhain, is as follows: Immediately after the reception of food the secretion begins, and increases in velocity up to a certain maximum, which it reaches from the first to the third hour after digestion has begun. The velocity then falls quickly un-

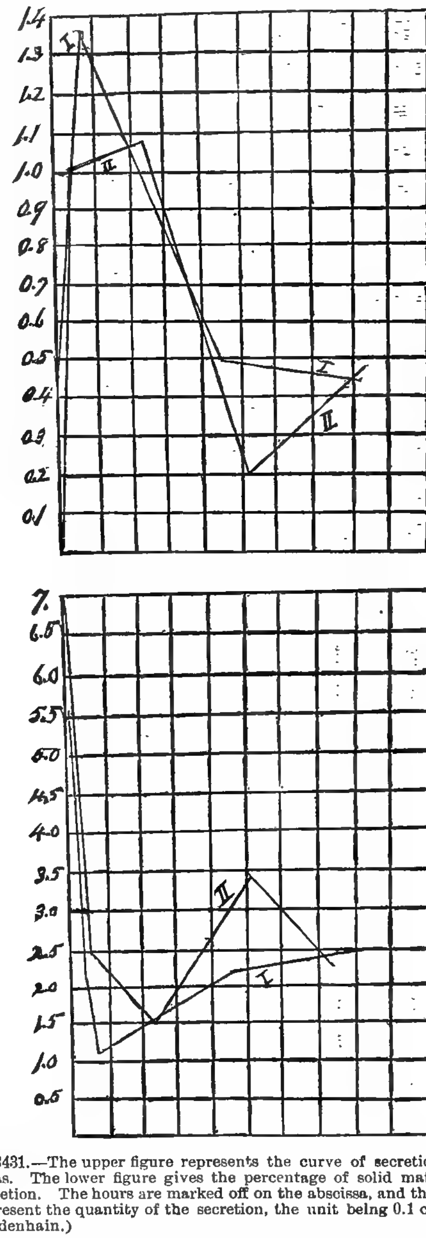


FIG. 3431.—The upper figure represents the curve of secretion of pancreas. The lower figure gives the percentage of solid matter in the secretion. The hours are marked off on the abscissa, and the ordinates represent the quantity of the secretion, the unit being 0.1 c.c. (After Heidenhain.)

til the fifth or sixth hour, after which there is a second increase of velocity up to the ninth or the eleventh hour. This second increased velocity is never so great as that which occurs in the first few hours. The flow of secretion then diminishes slowly until the sixteenth or seventeenth hour after digestion, when it again comes back practically to zero. Two of the curves obtained by Heidenhain are given in the upper portion of the accompanying figure. Heidenhain determined at the same

time the percentage of solid constituents in the secretion at the different hours, and the results are represented in the lower curves of the figure. An examination of these curves shows that as the velocity of the secretion increased the percentage of solid matter decreased, in this respect differing very much from the salivary secretion. The solid matter of the secretion is composed partly of organic constitutents and partly of salts; the variations given here are presumably variations in the organic material chiefly, though no analyses are given, so that the external characters of the secretion change during the hours of its flow; at first thick and coagulable, it becomes afterward thinner and more like the weak secretion from long-established fistulas, while toward the end of its flow—when the velocity is again very small—the percentage of organic constituents increases, giving again a secretion like that usually described as normal.

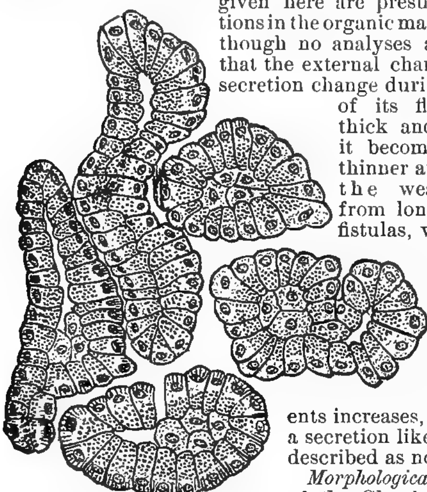


FIG. 3432.—Pancreas of Dog. (From Heidenhain.)

Morphological Appearance of the Gland in Rest and Activity. — Together with these changes in the flow of the secretion certain well-marked differences in the histological appearance of the gland have been noticed. A resting gland from a dog that has fasted for twenty-four hours or more, if hardened in alcohol and stained in carmine or Heidenhain's hæmatoxylin, shows in sections appearances represented in Fig. 3432. The cells of the alveoli show two distinct zones—an outer non-granular zone, which stains readily and contains the nucleus, and an inner granular zone facing the lumen; the matrix containing these granules does not stain at all, and is differentiated clearly from the stained outer layer. Heidenhain has shown, also, that in the outer non-granular zone the cells show a distinct striation, the lines disappearing at the commencement of the granular portion. If, now, the pancreas from a dog recently fed is treated in the same way within the first six or ten hours after digestion, marked changes in the relations of the two zones will be found to occur. The non-staining granular inner zone becomes smaller and smaller during this period, until in some of the alveoli it may entirely disappear. Together with this disappearance of the granular zone there is a corresponding increase in the staining non-granular portion, which becomes wider and wider, and may finally extend over the whole cell from basement membrane to lumen. The increase of the outer zone, however, does not quite keep pace with the consumption of the granular zone, so that during this period the cells and the alveoli or tubes of the gland become decidedly smaller, a condition of things represented in Fig. 3433.

During the second stage of digestion, within the tenth to the twentieth hour after feeding, the gland again comes back gradually to its resting condition. The cells increase in size, the inner granular zone is regenerated, and the outer clear zone of staining protoplasm forms now only a thin layer on the outer or basement membrane side of the cells.

The observations of Heidenhain on the hardened pancreas of the dog have been confirmed and extended by experiments of Kühne and Lea [13] upon the pancreas of a living rabbit. The secretion of the pancreas in the rabbit appears to be continuous, owing to the different character of the food and the time required for its digestion. When a portion of the pancreas in the living animal is examined under the microscope, two different kinds of alveoli or tubes may be seen, either in one field or in different parts of the specimen. In one represented in *A*, Fig. 3434, the outlines of the alveolus are smooth and even, the individual cells are not clearly distinguished from one another, and two zones can be seen—a clear homogeneous outer zone toward the basement membrane, and a granular inner zone toward the lumen. In the other, represented in *B*, Fig. 3434, the outlines of the

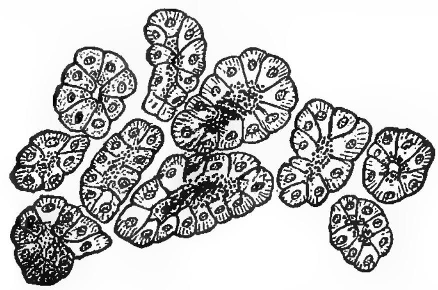


FIG. 3433.—Pancreas of Dog; six to ten hours after digestion has begun. (From Heidenhain.)

alveolus are notched or indented, and the division between the individual cells becomes more or less distinct in consequence of spaces or lines which appear between them. In the alveoli, also, the granular layer or zone is less conspicuous and the outer zone relatively greater. Kühne and Lea were able to show that this latter appearance represents the condition of activity, while the former, *A*, shows the resting state. When the gland was actively secreting, the notched alveoli were most numerous; and, furthermore, drugs which excite the secretion, jaborandi, *e.g.*, caused the alveoli to assume this shape, while atropine, which inhibits the secretion, brought about the smooth outline. When indifferent solutions, like normal salt solution or defibrinated blood, were forced into the duct of the gland under a low pressure, the liquid could be followed back, in the latter case, by the blood-corpuscles, into the small ducts and lumens of the alveoli; if the pressure was now taken off, the secretion of the cells forced back the defibrinated blood from the lumens, and in cases in which this occurred the alveoli assumed the notched appearance. For these reasons this latter condition may be considered as the state of activity. They saw alveoli pass from a state of rest to one of activity, and were able to determine that there was a movement of the granules toward the lumen. In the state of activity it was noticed, also, that the external zone of the cells, the non-granular zone, became distinctly striated, and if the striæ were seen during the resting stage they became more distinct in the state of activity. These experiments, together with those of Heidenhain, leave no doubt that the organic material of the secretion

A *B*

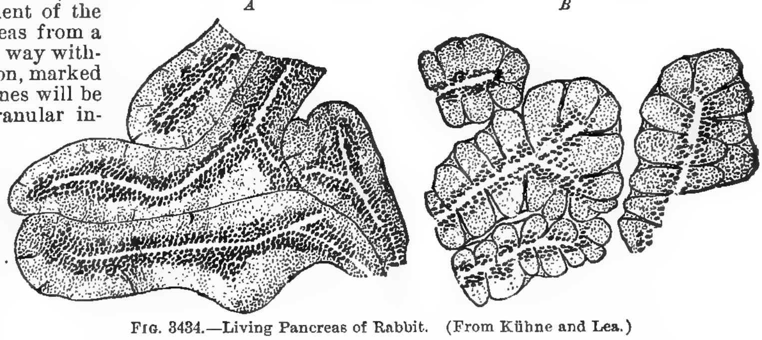


FIG. 3434.—Living Pancreas of Rabbit. (From Kühne and Lea.)

is formed from the granules of the inner zone, and that these in turn are derived from the protoplasmic material of the outer zone directly or indirectly; while during the act of secretion active changes of form take place in the cells, owing either to a contraction of the substance of the cells themselves or of some other element of the alveoli or tubes composing the gland.

Some recent experiments of Ogata[14] have given the same results with regard to the changes in the granular zone and size of the cells during rest and activity. Ogata's chief results, however, relate to the changes in the nucleus of the cell during rest and secretion, and the way in which the pancreatic cells that may be destroyed during the secretory process are replaced. Briefly presented, his results are as follows: He distinguishes in the nucleus of the resting cell two kinds of nucleoli—one staining with hæmatoxylin, like the nuclear membrane which he calls karyosmen, and of these there may be one or several; the other kind, usually a single nucleolus, he calls a plasmasoma, and it stains readily with eosin. In the cell outside of the nucleus he describes the two layers, granular and non-granular, already spoken of. In the inner granular layer the zymogen-granules are embedded in a clear, structureless matrix, which also extends throughout the non-granular zone, and forms what he calls the cell-stroma. In the external zone of the cell this cell-stroma contains granules of another kind from those of the inner zone; they are very fine and stain readily in nigrosin, and Ogata speaks of them as protoplasm. When the gland is stimulated in any way—by feeding, by stimulation of the medulla, or, best of all, by the injection of pilocarpin—very marked changes take place in the cell. The zymogen-granules disappear and the cells become smaller, as already described, but in addition to this a new body appears in the cell just outside of the nucleus; this he calls a "Nebenkern" (accessory nucleus) after Gaule, and he finds that it is formed by the passage of the plasmasoma out of the nucleus into the cell-body. One of two things may happen to this "Nebenkern." It may grow and finally be converted into zymogen-granules, to replace those used up in secretion, or it may develop an entirely new cell, with granules, nucleus, nucleoli, etc., and thus indirectly furnish new zymogen-granules. As the new pancreas-cell develops from the "Nebenkern," which in this case is a veritable cytoblast, the old cell dies away and finally disappears. These experiments of Ogata on the development of the new cell are in the line of recent researches on cell-growth and the function of the nucleus, but are too new to be accepted at present without further confirmation.

Formation of the Pancreatic Ferments.—Though the experiments just given indicate clearly that the ferments are derived from the granular material of the cells, we know that these granules do not themselves contain the ferments, but are composed of a material which probably at the moment of secretion suffers changes that result in the production of the ferments and other organic substances. This mother substance, from which the ferments or enzymes are formed, is spoken of usually as zymogen, but it is not easy to prove its existence. If a dog which has fasted for twenty-four hours—at which time, from what has been said, we know that the gland contains a large proportion of the granular material in the inner zone of the cells—is killed, and immediately after death a glycerine-extract is made of the pancreas, very little or no trypsin will be obtained from it. But if the gland is first allowed to remain in the air, in a warm place, for twenty-four hours, or treated with dilute acetic acid, then a glycerine-extract will be found to have a powerful tryptic action. The fresh gland then contains no trypsin ready-made, or only very small quantities of it, but a substance (zymogen) which can be readily converted into trypsin. The zymogen of the fresh gland is readily extracted by glycerine, and the zymogen of this extract can then be easily changed to trypsin by any one of a number of different methods—by simple dilution with water, by the passage of a stream of oxygen through it, by shaking with finely divided platinum-black, etc. The amount of trypsin or zymogen contained in the pancreas is found to vary according to the number of hours that have elapsed after digestion before the extract is made, and these variations are in the direction we should expect if the zymogen is contained in the granular material of the gland. Heidenhain has made a number of such experiments upon dogs, using in all cases a glycerine-extract of the gland, and has found that immediately after digestion the amount of zymogen or trypsin begins to sink, and reaches its minimum from the sixth to the tenth hour after the food has been taken, just the time at which, according to microscopical examination, the granular material of the inner zone is least abundant. After this the amount of ferment that can be extracted begins to increase, together with the increase of granular material that has been shown to take place in the gland, reaches its maximum at about the sixteenth hour, and then remains practically constant until the next meal is taken. Similar results have been obtained with the diastatic and fatty acid ferments. Grützner[15] found that both reached their minimum at about the sixth hour of digestion, and then slowly increased, the diastatic ferment reaching its maximum at the fourteenth hour, while the fatty acid ferment gradually increased in quantity until the fortieth hour. In the pancreatic gland, then, we are able to trace the genesis of the ferments, by microscopical and chemical means, more satisfactorily than in the salivary glands. The similarity in the appearance of the resting and active conditions of the living pancreatic and the living parotid gland lead us to believe that what has been ascertained for the former will hold good for the latter. On the contrary, what we know of the action of the nerves on the secretory activity of a gland has been derived almost entirely from a study of the salivary glands, and can be applied only by inference to the pancreas.

Action of the Nerves on the Pancreatic Secretion.—The secretion of the pancreas is, under normal conditions, probably a reflex act; it begins as soon as food has been received into the stomach, but the path of the reflex has not been determined. The centre for the reflex probably lies in the medulla, since direct stimulation of this organ increases the velocity of the secretion, and, furthermore, the secretion may be inhibited by the stimulation of certain afferent nerves, the vagus, for instance. Nevertheless the pancreas seems to be, to a large extent, an automatic organ, even more so than the salivary glands. The ganglia found in its substance act as local centres, which excite secretion in the gland after all nervous connection with the higher medullary centre has been severed. This secretion of the pancreas, after as complete section as possible of all nerves going to it, is of the nature of a paralytic secretion, and the views of Langley as to the mechanism of the paralytic secretion in the salivary gland will doubtless apply to the pancreas also. It is difficult to remove the pancreas from all nervous influence, since its nerve-branches are derived from the plexus hepaticus, lienalis, and mesentericus superior, and reach the gland along the walls of its blood-vessels, and are therefore less easily isolated than in the case of the salivary gland. For the same reason no satisfactory experiments, comparable to those given for the submaxillary and parotid glands, have yet been made upon the effect of direct stimulation of the secretory nerves of the pancreas. The best that can be done is to stimulate the secretory centre in the medulla and observe the effects. Experiments of this kind have shown that not only is the velocity of the secretion increased as the result of stimulation, but there is also an increase in the percentage of organic matter contained in it. These results indicate that here, as in the salivary glands, we have to deal with two kinds of nerve-fibres—secretory fibres, which regulate the velocity of the secretion, that is, the amount of water which passes out in a given time; and trophic fibres, whose business it is to form the organic materials of the secretion from the zymogen-granules, and at the same time start constructive metabolic processes in the cell, which result in the formation of new protoplasm and new zymogen-granules to take the place of those secreted.

The experimental evidence for the existence of these fibres is not very conclusive, though there is nothing to oppose such a view, and the analogy of the salivary glands, as before stated, leads us to believe that the nervous mechanism is essentially the same in both cases.

SECRETION IN OTHER GLANDS.—The most important outcome of modern researches on the phenomena of secretion, as illustrated in the salivary glands and pancreas, relates to the part taken by the extrinsic nerves of the gland in regulating and modifying the flow of the secretion, and to the histological changes which can be observed in the gland during its periods of rest and activity. It will be interesting to summarize briefly our knowledge of these two processes in some of the other glands of the body.

Stomach.—As far as the nervous mechanism of the secretion in the stomach is concerned, the results of investigations are very meagre. There is some evidence that the secretion of the gastric gland is under the influence of extrinsic nerves. For instance, it is stated that in cases of gastric fistula the mere sight of food has been observed to start the secretion of gastric juice. Unfortunately this observation has not been satisfactorily confirmed, and the flow of gastric juice, if it took place under such circumstances, might be an indirect result of reflex movements of the stomach, so that it cannot be considered as conclusive proof that the stomach can be reflexly excited to secretion. The well-known observation of Richet, who found that, in a man with a completely obstructed œsophagus, the chewing of sapid substances, sugar, citron, etc., caused a reflex flow of gastric juice, is also unsatisfactory, especially as similar experiments upon dogs have given negative results. On the other hand, direct stimulation of the vagus, or of the sympathetic branches to the stomach, has given only negative results. So, also, section of all the extrinsic nerves going to the stomach seems to have no direct influence on the secretion, and we are forced to believe that the intrinsic nervous apparatus, plexuses of Auerbach and of Meissner, are sufficient to regulate the normal secretion of these glands.

With regard to the histological changes in the gastric glands during secretion, our knowledge is much more satisfactory. From the microscopical study of glands taken from dogs in different stages of digestion, and hardened in alcohol, Heidenhain has been able to show that certain definite changes in the size and appearance of the cells can be observed. More detailed and trustworthy observations upon the living glands have been made by Langley and Sewall,[16] and Langley.[17] The experiments of these investigators were made upon the œsophageal and gastric glands of the frog and related animals. As is well known, the pepsin of the gastric secretion in the frog is chiefly formed in the œsophageal glands, and it has been found that these glands suffer changes during secretion which are very similar to those already described as occurring in the parotid gland and the pancreas. If these glands are made to secrete, either by mechanical stimulation or by the action of food, the cells, which in the resting condition were granular throughout, begin to lose their granules. The disappearance takes place from the periphery inward, so that soon the cells show an outer non-granular, and an inner granular, zone, owing to the fact that the granules toward the exterior travel inward to the lumen, as those formerly occupying that position are used up in making the secretion. The secretion of pepsin goes on as long as digestion continues, and Langley has proved that during the latter half or two-thirds of the digestive period the granules begin to increase in number, showing that two processes are going on simultaneously, viz., the conversion of the zymogen granules into pepsin and its discharge into the duct of the gland, and the manufacture of new zymogen granules from the protoplasm of the cell. It may be assumed that these two processes go on throughout the whole period of activity, and that in addition there is a continual formation of new protoplasm in the cell from the food offered by the lymph, this being a necessary preliminary step to the formation of new zymogen granules. In the first stages of digestion it is probable that the conversion of zymogen, or pepsinogen as it is called in this particular case, to pepsin overbalances the other processes, and the cells therefore diminish in size. The other two processes, however, soon equalize this loss of substance, and in the later stages of digestion lead to an actual increase in the size of the cells. The cells, therefore, do not have to wait until the period of activity is passed to make up the loss of substance suffered during secretion, but the restorative processes go on simultaneously with the secretion, so that at the end of digestion the gland-cells are nearly or quite as large as the resting cell.

Kidney.—We have no satisfactory evidence of the existence of secretory nerves in the kidney. Eckhard held such a view,[18] and thought that these fibres have their origin from a secretory centre in the medulla, pass down the cord, and reach the sympathetic chain by the communicating branches in the upper thoracic region. Their path from the sympathetic trunk to the kidneys was not definitely known, but Eckhard supposed it to be through the circumvascular plexus around the aorta. He was led to this conclusion chiefly from the fact that, after separation of all the nerves going to the kidneys, as far as they could be distinguished anatomically, stimulation of the medulla still caused an increased secretion of urine. The explanation of this he found in the stimulation of secretory nerves, since the only other theory which could account for it, namely, variations in arterial pressure from the stimulation of the vaso-motor centre, was shown by him to be insufficient, the variations in arterial pressure not being constant.

As far as Eckhard's work has been repeated by later observers, the result has been to weaken his theory of special secretory nerves. The results obtained from section of the cord, stimulation of the medulla, etc., find a simpler explanation in the vaso-motor changes which follow such experiments, and the variations in the quantity of secretion are now usually believed to be the result of the increased or diminished blood-flow through the kidneys.

With regard to the mechanism of the secretion of urine, at least two different views are held at present among physiologists. According to the theory of Ludwig, the secretion of urine is the result of simple filtration and diffusion. In the blood-vessels of the glomeruli the conditions are such that not only is there a filtration of water and salts, but also of the specific elements of the secretion from the blood into the kidney tubules, and this diluted urine in its passage along the uriniferous tubules, by diffusion with the surrounding lymph, becomes concentrated to its normal strength. According to the other theory, first advocated by Bowman, and since upheld by Heidenhain, the secretion of water and salts takes place in the glomeruli, while the specific elements of the secretion are eliminated from the blood by the epithelial cells of the tubules. According to Heidenhain, we have to deal in both cases with a functional activity of the epithelial cells of the kidney, a true secretion as opposed to Ludwig's idea of a simple physical process in which the cells take no active part. The question of the truth or error of Ludwig's view seems to turn mainly on the effect of variations in arterial pressure in the kidneys on the quantity of the urine formed. According to his theory an increase in the arterial pressure should always be accompanied by an increased secretion, and *vice versa*. Heidenhain contends that this is not true, that in some cases increased pressure in the kidney-vessels is not followed by increased secretion, that all the numerous experiments made by Ludwig and his pupils to demonstrate this point simply show that the quantity of the secretion (quantity of water secreted) depends, not on variations in pressure in the arteries of the kidney, but upon variations in the velocity of the blood-flow, an increased velocity of the blood being accompanied invariably by a greater secretion. The labors of Heidenhain, especially his well-known experiments on the secretion of indigo-carmine, have pretty well established the second part of Bowman's theory, that the secretion of the specific elements of the urine takes place through the action

of the cells of the uriniferous tubules; and there is a continually increasing amount of evidence, from various sources, which goes to support the first part of the theory as modified by Heidenhain, viz., that the secretion of the water is also the result of the functional activity of the epithelial cells, most probably those of the glomeruli. There is no evidence of any histological changes in the appearance of the gland-cells during rest and activity of the kind described for the salivary glands, the pancreas, and the glands of the stomach.

Mammary Glands.—Without going into the details of the discussion as to the action of nerves in the production of the mammary secretion, it can be stated that we have abundant evidence that this secretion is, to some extent, capable of being influenced by the nerves. But whether the effect of the nerves is a direct one upon the secreting cells, making them true secretory nerves, or whether it is an indirect effect through modifications of the blood-flow, as in the kidney, is an entirely unsettled question, and we have no positive evidence one way or the other.

Well-defined histological changes of the glandular epithelium, in different stages of activity, have been described by Heidenhain. The changes, however, seem to lie chiefly in the direction of variations in the size of the cells lining the alveoli, and in the amount of fat present in them; so that, while we are justified in believing that the organic products of the secretion, at least, are the result of metabolic changes in the gland-cells, there is nothing in the mechanism of the formation of these products, such as the production of zymogen granules, which would bring this process into close relation with the metabolic changes in other glands. The inorganic constituents of the mammary secretion, as already stated from the analysis of Bunge, differ very widely from those of the blood in percentage proportion, the difference being most marked in the proportion of CaO, P_2O_5, and Na_2O. In the ash of dog's blood there is 45.6 per cent. Na_2O, 0.9 per cent. CaO, and 13.2 per cent. P_2O_5; while in the ash of dog's milk there is 6.1 per cent. Na_2O, 34.4 per cent. CaO, and 37.5 per cent. P_2O_5—a difference which would seem to indicate an active secretion on the part of the gland-cells.

Sweat-glands.—It has been demonstrated beyond doubt that the sweat-glands are provided with proper secretory nerves. Stimulation of the sciatic or brachial plexus in the lower animals causes drops of sweat to form on the balls of the feet. It has been clearly shown that this is not owing to vaso-dilatation, or to any contraction of the tissue simply pressing out the sweat from the gland-ducts. The secretion may be obtained as long as twenty minutes after amputation of the leg, or after clamping the femoral artery, and Luchsinger has shown that the glands may be made to secrete continuously from nerve stimulation for many hours. The nerves of the glands may be stimulated either directly, or reflexly through the central nervous system, and it has been found that pilocarpine and atropine act upon the secretion of these glands just as they do upon the salivary glands.

The precise path of the secretory fibres for the balls of the feet, in cats and dogs, has not been determined. It seems most probable that—for the lower limbs—they leave the spinal cord through the rami communicantes of the three lower dorsal and four upper lumbar nerves, and reach their destination through the sympathetic system. Whether or not there is a general secretory centre for all the sweat-secreting nerves of the body, is unknown; according to Luchsinger the evidence at hand indicates a number of spinal centres as the points of origin of the secretory nerve-fibres. According to Ott [19] the cells show histological changes, after profuse secretion, similar to those found to occur in the salivary glands. From the study of specimens hardened in alcohol after stimulation for two hours and a half, he states that the cells are smaller, more granular, and stain more readily in carmine than those of the resting gland. The increase in the number of granules, as in the case of the salivary glands after hardening in alcohol, is probably the result of the action of the alcohol, and it is possible that if these glands were studied while fresh, the production of secreting material in the form of granules which dissolve and disappear during secretion, as in the pancreas and salivary glands, might be demonstrated. A general survey of the action of the glands of the body, other than the salivary glands and pancreas, teaches us, in fact, that the general theory of secretion, as obtained from the study of these glands, which has been presented in some detail in this article, is not generally applicable. After a careful comparison of the physiology of the different glands, as far as is known, one is forced to the conclusion of Heidenhain, that a general theory of secretion cannot be made at present, if indeed it is possible at all. As he points out, we can make a general theory of the physiology of muscular or contractile substance. Some of the common properties upon which such a thing can be based may be mentioned briefly. When stimulated, a contraction or shortening always results, never a dilatation, as might seem theoretically possible. The chemical changes which accompany the contraction are doubtless closely related. The metabolic changes in voluntary and involuntary muscles, if not identical, must be very similar, and it is not going too far, perhaps, to say that the chemical changes in the substance of the contracting amœba are of essentially the same character as those in the voluntary muscles. So, too, we have theories of the ultimate structure of contractile substance, such as that of Engelmann, and of the mechanism of its action in contraction, which are applicable to the contractile material in protoplasms wherever found. If we seek for any such common properties among the secreting tissues, the search will be in vain. As far as the secretions of our own bodies go, the two most general characteristics that have been established are, that the secretion is the result of metabolic changes in the gland-cells, as shown by chemical and histological examination of the secretion and of the cells; and furthermore, that the action of the cells is under the influence of the nerves. But as we have already seen in some of the glands, we cannot prove the existence of secretory nerves, or perhaps the evidence is entirely against their existence; while, on the other hand, the generous definition of secretion includes certain liquids, such as the serous transudations or the lymph, the formation of which, according to general belief, is not dependent upon any functional activity of epithelial cells, although evidence has been given in this article to show that this general belief may be erroneous. Indeed, the very definition of secretion as given in the beginning of this article, the definition generally accepted, is an artificial one, which does not clearly characterize or differentiate secretion from other physiological processes. The second part of the definition, viz., that the secreted substance, after its separation from the blood, is poured out on a free epithelial surface, seems to be an arbitrary distinction. In the liver, for instance, we have an example of a gland which forms a true secretion, bile, according to the definition. The materials for the secretion are prepared in the liver-cells, and poured out on the free epithelial surface of the bile-ducts. But the liver-cells also prepare another substance, glycogen, which is finally poured out into the blood-vessels, and the processes in the two cases would seem to be essentially the same, though no one speaks of the latter as a secretion. If it be urged in this particular case that the glycogen is of direct nutritive value to the body-cells, food-matter, in fact, while the bile is only of secondary value in its action on the food-stuffs in the intestine, such a distinction cannot be accepted as general. For in some of the undoubted secretions, such as saliva and pancreatic juice, we have albumins present which must finally be absorbed from the alimentary canal, and serve as nutritive material.

The formation of the organic products of the secretions, whenever such products occur, is essentially similar to the ordinary nutritive processes in all the cells. The food-material given by the lymph is assimilated into new protoplasm of the kind characteristic of the cell, and this then undergoes retrograde changes of a katabolic nature, which result finally in the production of the zymogen material. Perhaps an essential difference between the metabolism in gland-cells and the nutritive changes

in the cells of the tissues generally, may lie in the fact that, whereas in the cells generally the end products of katabolism are CO_2, H_2O, and some simple nitrogenous residue, in the gland-cells the series of katabolic changes, at least in those glands which are distinguished by the formation of organic material in their secretions, ends in the formation of these more complex products ; the oxidations or dissociations are less complete. In those glands, like the kidney, in which the cells seem only to pick the secreted material out of the blood, we have no theory at all of the means by which this is accomplished, nor do we know whether or not the process is associated with any metabolic changes in the cells themselves. With regard to the active secretion of water and of salts by gland-cells, or epithelial cells of any kind, no satisfactory theory is yet offered. Heidenhain's view of the action of the secretory fibres in the salivary glands, to account for this process, will not apply at all to the similar process of water formation in the kidney, nor to the formation of lymph by the endothelial cells of the capillaries, if this is demonstrated to be true. *W. H. Howell.*

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SEDATIVES. There is a class of remedies called sedatives, or depressants, the action of which is to quiet overexcitement of an organ or group of organs. Like all other divisions of therapeutic agents, that of the sedatives cannot be strictly defined, as it embraces many remedies which exert a sedative action only in certain cases and upon certain organs. Thus digitalis is a vascular sedative, while at the same time it is a powerful cardiac tonic. Again, a remedy may be either an excitant or a sedative, according to the dose, or to the length of time that has elapsed since its administration. Opium, for example, may be employed as either a stimulant or a sedative, according to the dose, or the condition or idiosyncrasy of the patient.

The group of remedies which may be given to produce sedation is a very large one, and may be divided into subclasses according to the mode and degree of action of the medicaments comprised therein, or to the special organ or group of organs acted upon. Thus we have nervous sedatives, emollients, analgesics, anæsthetics, anaphrodisiacs, hypnotics, etc. We shall here consider briefly the nervous, respiratory, circulatory, gastric, urinary, and local sedatives. For a further consideration of the remedies embraced in this class, the reader may consult the articles Anodynes, Antispasmodics, Anaphrodisiacs, Anæsthetics, and Hypnotics, in the earlier volumes of this HANDBOOK.

NERVOUS SEDATIVES.—These remedies are employed to quiet abnormal excitability of the brain and spinal cord, either directly by their action upon the nervous centres, or indirectly by stilling pain or removing any other cause of the exalted nervous state. Among the general sedatives may be mentioned rest, warm baths, alcohol in small doses, especially in the form of malt liquors, tobacco smoke in moderate quantity, for those who are habituated to its use, valerian, camphor, hyoscyamus, the bromides, chloral, opium, and all the hypnotics and anodynes. Among spinal sedatives gelsemium and calabar bean are familiar examples.

RESPIRATORY SEDATIVES.—These are remedies which serve to relieve dyspnœa and quiet cough. These effects may be obtained by removing the cause, whether it be in the lungs, the liver, the heart, the larynx, or the ear, by obtunding the respiratory centre, or by reducing the irritability of the terminal nervous filaments. Belladonna, opium, oxalate of cerium, quebracho, and the expectorants generally, may be mentioned as examples of the respiratory sedatives.

CIRCULATORY SEDATIVES are agents which reduce the frequency and the strength of the cardiac action, and diminish the volume of blood in the vessels. Some remedies, like digitalis, increase the strength of the cardiac pulsations, while they reduce the flow of blood in the vessels. These are called vascular, as distinguished from cardiac, sedatives. The principal circulatory sedatives are cold, veratrum viride, aconite, ergot, digitalis, and opium.

GASTRIC SEDATIVES are employed to relieve pain and vomiting. They act by reducing local irritation in the stomach itself, or by a direct effect upon the vomiting centre. The most important are cold, opium, bismuth, oxalate of cerium, chloroform, creasote, atropine, hydrocyanic acid, and ipecac, calomel, or arsenious acid in minute doses.

URINARY SEDATIVES.—These are agents which render the urine bland and unirritating, or which lessen pain and irritability of the bladder. Alkalies, water in large amounts, copaiba, thymol, belladonna, opium, and warm sitz-baths are some of the remedies of this class.

LOCAL SEDATIVES.—In this class are all those remedies which act directly upon the terminal nerve-filaments in any locality, diminishing their sensibility. Many of the gastric and urinary sedatives, already referred to, are examples of this class of agents; but the term, in its more commonly understood application, refers to remedies acting upon the skin and accessible mucous membranes. These agents are employed to relieve pain and itching of the parts to which they are applied. Aconite, belladonna, opium, chloral-camphor, carbolic acid, hydrocyanic acid, chloroform, lead-water, cocaine, and cold, in the form of ice or evaporating lotions, are familiar examples of this class of remedies. *T. L. S.*

SEGMENTATION OF THE BODY. As stated in the article Fœtus, vol. iii., p. 177, the segmentation of the body depends primarily upon the divisions of the muscles to which the segmental divisions and arrangements of the other parts are secondary. The evidence we at present possess in regard to the evolution of vertebrates indicates that they were derived from forms allied to the segmented worms (Annelida). These animals are, in fact, the only ones besides the vertebrates whose bodies have a segmentation. In the annelides all the segments are decidedly similar, and though we see, here and there, a group of them modified, all in a like manner, as for instance in the clitellus of the earth-worm, yet we do not see anything strictly comparable to the division of the segments in vertebrates into two main groups, one comprising the segments of the head, the other the segments of the rump. Consequently, we must say that the possession of a head developed by the condensation of a number of segments is a feature exclusively pertaining to vertebrates. This involves the corollary that no invertebrate possesses a true head, if we take the definition of that term from vertebrates. The homologous parts, or, to be more precise, the segments homologous with those of the vertebrate head were, of course, present in the invertebrate ancestral form.

These considerations render it evident that to elucidate the segmentation of the higher types we have to determine, *first*, the primitive character of the segments; *second*, the number and modifications of the segments in the head; and *third*, the number and modifications of those in the rump. It is impossible to enter here upon a full discussion of this abstruse problem. We can only state briefly the essential results at present known.

First. As to the primitive arrangement. We must assume that in the ancestral type of vertebrates the body cavity was continuous ventrally throughout both the region of the head and of the rump. The dorsal portion of the body cavity was divided into the muscular segments or myotomes. Each pair of myotomes, of course,

represented a single segment. For each segment there were four nerves, two on each side; of these two, one sprang from the ventral side of the nervous system and passed to innervate the myotome of that side; this nerve persists, in man, in the series of spinal nerves as the anterior motor root; the other nerve of the same side sprang from the dorsal part of the central nervous system, passed outside of the myotome, and innervated both the walls of the body cavity and also an epidermal sense-organ upon the surface of the segment. This nerve is represented in man by the sensory root of a spinal nerve.

The evolution of a heart upon the ventral side of the body may be regarded as having been, presumably, the first definite step toward the evolution of the head, because the heart lay a little distance behind the mouth, so that there were a few segments in front of the heart and an indefinite series behind it. But the heart was so constructed that it pumped the blood forward; it must have been advantageous for the blood to be purified before it reached the tissues to which it was forwarded by the heart; certainly the purifying apparatus *was* actually developed in the segments in front of the heart, for they only were gill-bearing. These respiratory needs were satisfied by the development of gill-clefts, which permitted a freer circulation of water and an increased exposure of the superficial blood-vessels of the branchiæ, and so effected a more perfect aeration of the blood. The division of the body into a gill-bearing and a not gill-bearing region may be designated as the second step in the evolution of the head. In fact, the branchiate segments are the head segments. The presence of gill-clefts has led to many modifications of the primitive segmental arrangements, and these complications have been greatly increased by the extreme condensation of the head segments and also by the displacement of certain parts, as well as by the disappearance of others, and, finally, through the annexation by the head of three or four segments properly belonging to the rump.

Second. Number and characteristics of the cephalic segments. The determination of the number of segments in the vertebrate head has long occupied the attention of naturalists. In the beginning of this century the vertebræ were usually taken as the means of counting segments, for at that time the fact that segmentation depends on the myotomes, and that therefore the vertebræ are parts of the inter-segmental structures, had not been ascertained. Hence, in this period, we find discussion turning upon the number of supposed vertebræ in the head. The earliest suggestion of a vertebral theory of the skull, known to me, is that of Burdin, independently made about the same time by Heilmeyer. These authors compared the skull to a single complex vertebra. The first to announce the modern theory of there being several segments in the head, was Oken, who conceived that there were four cranial vertebræ. Goethe adopted this hypothesis with some infelicitous modifications of his own. He counted six vertebræ, of which three belonged to the facial apparatus. As to the number of vertebræ, there is a very extensive literature, which possesses an interest purely historical. Let it suffice, therefore, to state aphoristically that three vertebræ were advocated by Spix, Meckel, Burdach, and Carus; four by Oken, Bojanus, and Owen; six by McClise; and seven by Geoffroy.

The discovery of the real segmentation was started by Gegenbaur, continued by Balfour, and elaborated by Marshall, Spencer, Dohrn, van Wijhe, Froriep, Beard, and others. Gegenbaur recognized the segmental arrangement of the cranial nerves, and endeavored to ascertain their primitive number and arrangement. This was a great step in the right direction. Subsequent writers have studied in more detail the development of the cranial nerves, giving especial attention to their relation to the primitive segments or myotomes, which embryology shows to be temporarily present in the head. These researches have led to the conclusion that the two nerves, on each side of each segment, have remained distinct, whereas in the rump they are transformed into roots which unite into one nerve. The dorsal or sensory nerve in the head runs to a sensory organ in the integument, which organ is situated just above the opening of the branchial cleft of the same segment. This nerve also possessed three branches, one running above the cleft, one in front of it, and one behind it. The ventral or motor nerve ran to the myotome of its segment. The number of myotomes, in at least all the higher vertebrates, to be found in the head of the embryo is twelve, and there is some reason for thinking that there may once have been a thirteenth in front of those which we can still detect. Now, the majority of these myotomes disappear very early, and the nerves which belong to them have disappeared also. In fact, no trace of the nerves of several of the myotomes has been observed. We see that the majority of the branchial sense-organs are also only temporary embryonic structures. But the sensory nerves, as they have other branches than those to the branchial sense-organs, are left with functions to perform, and accordingly are preserved in the adult. It is a misnomer to call the ventral cephalic nerves sensory only, because they carry motor fibres likewise, which supply the muscles developed in the gill-arches independently of the myotomes. A brief explanation is requisite in regard to the three posterior segments of the head, and in regard to the seventh, eighth, ninth, and tenth segments. These two sets of myotomes have each a single nerve only. The seventh to tenth segments correspond in our enumeration to the sixth to ninth myotomes, one myotome being supposed to have been lost in front. The nerve of these segments is shown by its development in the embryo to be the product of the fusion of four nerves; it is known to anatomists as the vagus. The nerve of the eleventh to thirteenth segments (tenth to twelfth myotomes) is the hypoglossus, which is produced by the fusion of three distinct nerves, each of which has two roots, and possesses in the embryo all the essential features of a true spinal nerve. It follows that the three corresponding segments are not truly cephalic, but have been annexed from the region of the rump by the head, and added to the occipital region. Since the differentiation of the head commenced with the evolution of branchial clefts, it has resulted in the evolution of the head preceding that of the vertebræ; hence there is no trace whatever of vertebræ in the head, except in the hypoglossal region.

The table on the next page presents, in a compact form, all the essential facts yet gathered in regard to the segmental disposition of the organs of the head.

The characteristics of the head segments are, first, the development of gill-clefts; second, the fact that the dorsal and ventral nerves do not become roots, but remain distinct; third, the absence of vertebræ. There are many other peculiarities which might be signalized, but the three named seem to me the most essential. There are *very* numerous secondary modifications, which are in large part indicated in the following table.

Third. Rump segments. The number of segments in the rump is very variable. In man there are thirty-seven or thirty-eight, of which four or five constitute the temporary tail, and disappear during the second month of fœtal life. The characteristics of the rump may be said to be the conversion of the nerves into roots; the development of true vertebræ; the great development of myotomes, which produce the skeleton muscles; and, finally, the segmental organs or excretory tubules, which constitute the primitive kidney or so-called Wolffian body, and of which there is, at first, at least one pair in each segment. It must be added that not every rump segment appears to necessarily have segmental organs.

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TABULAR ANALYSIS OF THE SEGMENTATION OF THE VERTEBRATE HEAD.

Segment.	Myotome.	Cleft.	Sense-organ.	Ganglion.	Dorsal nerve.	Supra-branchial branch.	Ventral nerve.	Muscles.
I.		None	Olfactory	Olfactory	Olfactory	None	None	None.
II.	1	None (or Hyphysis?)	Branchial*	Biliary	Radix longa of ciliary gangl.	Ophthalmicus profundus.	Motor oculi	Recti super. inter. and inf. and obliq. inf. of eye.
III.	2	Mouth	Branchial*	Gasserian	Trigeminus	Ophthalmicus superficialis sine port. facialis.	Trochlear	Muscle of mouth, obliq. sup. of eye.
IV.	3	Hyoid	Branchial*	Facial	Facialis†	Part. facial of ophthal. sup. and ramus buccalis.	Abducens	Rectus externus.
V.	4	None	Auditory	Auditory	Auditory	None	None	None.
VI.	5	First branchial...	Branchial*	Glosso-pharyngeal.	Glosso-pharyngeus.	Supra-temporal...	None	None.
VII.	6	....	....	....	....	Supra-temporal ..	None	None.
VIII. IX. X.	7 8 9	Second to fifth branchial.	Branchial*	Vagus i. to iv....	Vagus i. to iv	(Of vag. ii. to iv., lateral nerve??)	None	None.
XI. XII. XIII.	10 11 12	None	None	Abortive	Abortive roots....	None	Hypoglossus	None.

* Aborts.
† Dohrn and Beard regard the facial nerve as double, and think that one myotome and one cleft are lost between the mouth and hyoid cleft.

Charles Sedgwick Minot.

SEGMENTATION OF THE OVUM. There follows upon the impregnation of the ovum a remarkable process known as the segmentation. This term is used to designate the series of divisions of the impregnated ovum into a number of cells, of which all the cells of the future animal are the direct descendants. Common usage applies the term only up to the time of development, when the two primitive germ-layers are clearly differentiated and the first distinct organs are beginning to appear. The word was introduced before the masses into which the ovum divides were known to be cells. The cleavage of the ovum was described by Prevost and Dumas, and again by Rusconi in 1836.[27] Since then it has been investigated very frequently. The cell doctrine dates from 1839.

As stated in the article on Impregnation (vol. iv., p. 5), *the nucleus of the impregnated ovum is formed by the union of the male and female pronuclei.* Van Beneden had affirmed that there was no real union in the eggs of Ascaris, but Carnoy[13] has shown that Van Beneden's observations were incomplete, and Zacharias[26] states that they were so very defective as to be fundamentally erroneous, and that in reality the eggs of Ascaris offer another proof of the actual union of the pronuclei. It seems to me safe to accept the generalization just made as to the origin of the first or *segmentation nucleus.*

The position of this nucleus is determined, first, by the form of the egg; second, by the distribution of the formative (ectodermal) and nutritive (entodermal) yolk. In *round* eggs, with very little yolk—alecithal ova—such as those of Echinoderms, the nucleus lies nearly in the centre. It is commonly stated to lie *exactly* in the centre, but I must question the accuracy of such statements. When there is an evident differentiation of nutritive and formative yolk—telolecithal ova—the nucleus is always eccentric and its eccentricity increases with the amount of yolk, for it always tends to approach the so-called "animal" pole, where the protoplasmatic or formative yolk is accumulated. In *oval* eggs with little yolk the nucleus lies in the middle of the long axis, as in Nematod eggs, but whenever there is differentiation of an animal pole the nucleus tends to approach it. In brief, we may say that the *segmentation nucleus takes the most central position possible with regard to the protoplasm of the ovum.* The vitelline granules are not regarded as protoplasm, hence, when they accumulate they may increase the bulk on one side of the nucleus without otherwise disturbing the radial distribution of the protoplasm around it.

After the segmentation nucleus is formed there occurs a pause, which lasts, according to observations on several invertebrates, from half to three-quarters of an hour. During this period the yolk gradually expands again (having contracted during impregnation), and also acquires a radiating appearance starting from the nucleus as a centre. The radiation is due to the arrangement of the protoplasmatic network, and the conforming distribution of the yolk granules. The physiological mechanism is unknown which causes this radiation and the other radiations of protoplasm which appear during cell divisions. Morphologists often speak loosely of nuclear attraction as the cause, but it need hardly be pointed out that this notion is, physiologically speaking, vague and crude. The monocentric radiation soon disappears and is replaced by a dicentric radiation, which marks the end of the period of repose, and the commencement of the first division of the ovum. For figures see Hertwig's memoirs.[18, 19]

The external appearances of segmentation in the living ova vary, of course, especially according to the amount and distribution of the yolk material. The appearances in holoblastic ova with very little yolk are well exemplified by Limax campestris. Mark's description[22] is, nearly in his own words, as follows: In Limax, after impregnation, the region of the segmentation nucleus remains more clear, but all that can be distinguished is a more or less circular, ill-defined area, which is less opaque than the surrounding portions of the vitellus. After a few moments this area grows less distinct. It finally appears elongated. Very soon this lengthening results in two light spots, which are inconspicuous at first, but which increase in size and distinctness, and presently become oval. If the outline of the egg be carefully watched, it is now seen to lengthen gradually in a direction corresponding to the line which joins the spots. As the latter enlarge, the lengthening of the ovum increases, though not very conspicuously. Soon a slight flattening of the surface appears just under the polar globules; the flattening changes to a depression (Fig. 3435), which grows deeper and becomes angular. A little later the furrow is seen to have extended around on the sides of the yolk as a shallow depression, reaching something

more than half-way toward the vegetable or inferior pole, and in four or five minutes after its appearance the depression extends completely around the yolk. This annular constriction now deepens on all sides, but most rapidly at the animal pole; as it deepens it becomes narrower, almost a fissure. By the further deepening of the constriction on all sides, there are formed two equal masses, connected by only a slender thread of protoplasm, situated nearer the vegetative than the animal pole, and which soon becomes more attenuated, and finally parts. The first cleavage is now accomplished. Both segments undergo changes of form; they approach and flatten out against each other, and after a certain time themselves divide.

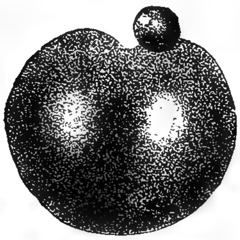

FIG. 3435. — Ovum of Limax Campestris during the First Cleavage. Magnified 200 diameters. The envelopes are not drawn in. (After E. L. Mark.)

The division of *all* ova, so far as at present known, is indirect (karyokinesis, mitosis), there being nuclear spindles, amphiasters, etc. The dicentric radiation just mentioned marks the appearance of the first amphiaster.

The plane of the first division determines those of the subsequent divisions, and also of all the axes of the embryo; * it is itself determined by the position of the long axis of the first amphiaster or nuclear spindle, to which it is at right angles. It, therefore, is a matter of great interest to ascertain what factors determine the position of the first spindle, or, in other words, the axis of elongation of the segmentation nucleus. So far as at present known, there are two factors: 1, Relation to the axis of the ovum; 2, position of the path taken by male pronucleus to approach the female pronucleus. The axis of the ovum is fixed before impregnation; it passes through the centre of the animal, and that of the vegetable pole. Usually the nuclear spindle which leads to the formation of the polar globule has its long axis coincident with that of the ovum, hence the point of exit of the polar globule marks one end of the ovic axis. *The first amphiaster or spindle is always at right angles to the ovic axis.* This, however, leaves the meridian plane undetermined. Roux,[24] from a series of interesting experiments on frogs' ova, concludes that the plane is fixed by the path of the spermatozoon. So far as I know, this idea was first suggested by Selenka, in 1878, in his paper on "The Development of Toxopneustes Variegatus;" compare also Mark, *l. c.*,[22] p. 500. In the frog's egg the path of the male pronucleus is marked by a line of pigment, as was first described by Van Bambecke,[28] and has been well figured by O. Hertwig.[29] The pigment renders it easy to ascertain the position of the male road, even after the first cleavage of the ovum. This Roux has done in sectioned ova, and from his experiments and observations reaches this result: *The long axis of the first segmentation spindle lies in a plane, which passes through the axis of the ovum and the path of the male pronucleus.* If Roux's conclusion is confirmed, it will become of fundamental importance. Yet there must be other factors which can at least replace the male pronucleus in this special rôle, since the development of parthenogenetic ova, in which there is no male pronucleus at all, is equally determinate. It is probable that the distribution of the protoplasm is the real cause determining the position of the nucleus; thus in oval eggs the spindle lies in the direction of the long axis; it is quite probable that if the male pronucleus has the effect ascribed to it by Roux, it produces it indirectly by altering the distribution of the protoplasm within the ovum; that such alteration takes place is indicated by the occurrence of the male aster.

After the spindle is formed it divides, and the daughter nuclei form the centres of two segmentation spheres or cells. Each of these cells again divides in the meridional plane at right angles to the first. The third cleavage is at right angles to both the first. If an egg is placed with its axis vertical, the planes of the first and second divisions both will be vertical, but that of the third will be horizontal.

Segmentation occurs with many variations, according to the manifold modifications of ova, and these varieties we must now briefly consider.

It has long been customary to describe the various modifications of segmentation as belonging to three types: 1, *regular* or *equal*; 2, *unequal*; 3, *partial*. It has become traditional to state that the first type is found in the Echinoderms, etc., and is characterized by the regular and uniform division of the cells (segments), so that there are first two, then four, eight, sixteen, thirty-two, sixty-four, and so forth, cells. But this statement is fundamentally erroneous. The frog's ovum is taken as the example of the second type, and the bird's ovum of the third. This classification is most unfortunate, for it leads attention off from *the essential* feature of the process of segmentation, as first pointed out by Minot in 1877. Minot[23] established the generalization that *in all animals the yolk undergoes a total segmentation, during which the cells of the ectoderm divide faster and become smaller than the cells of the entoderm* (Fig. 3436). There are, however, a small, and it seems diminishing, number of cases where the process of segmentation and the formation of the germ-layers is imperfectly understood, and which cannot yet be shown to conform to this generalization. "All the known variations in the process of segmentation depend merely upon: 1, The degree of difference in size between the two sets of cells; 2, the time when the difference appears; 3, the mode of development, whether polar or by delamination,* either of which may or may not be accompanied by axial infolding. In Gasteropods, Planarians, Calcispongiæ, Gephyrea, Annelida, fish, birds, and Arthropods the difference is great and appears early. In Echinoderms, most Cœlenterates, some sponges, in Nematods, Amphibians, etc., it is less marked and appears later" (Minot, *l. c.*).

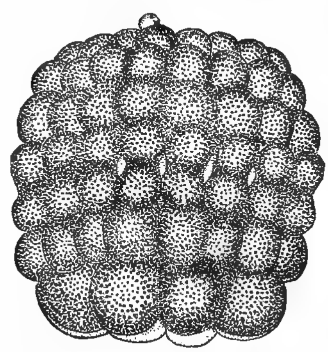

FIG. 3436.—Ovum of Amphioxus Lanceolatus during Segmentation; stage with 88 cells. Magnified 280 diameters. (After Hatschek.) One pole is occupied by large, the other by smaller, cells.

In most cases the entodermic cells are very decidedly larger and less numerous than those of the ectoderm. This distinction is obviously necessary on account of the mutual relations of the two primitive layers. The ectoderm has to grow around the entoderm, which it can do only by acquiring a greater superficial extension—this the ectoderm accomplishes by dividing very quickly at first into small cells. After the entoderm is fully enveloped it may then continue to grow until its superficies is much greater than that of the outer layer, within which, however, it still finds room by forming numerous folds; thus is gradually reached the condition in the higher adult animals, where the intestine sometimes has an enormous surface, but is nevertheless contained in body-walls covered by ectoderm presenting much less surface. It is, therefore, only during the early stages of segmentation that we find the entoderm expanding more slowly than the ectoderm.

The degree of difference in size between the ectoderm and

* In certain cases, notably in birds, as described below, the segmentation is irregular; and it is therefore not known yet whether the scheme of arrangement of the cleavage planes here given can be applied to *all* ova or not. We may say, however, that the scheme is the primitive one, from which any modifications arose phylogenetically. The best discussion of the subject is by Whitman.[1]

* There is not a single satisfactory description of the process of delamination known to me, and one cannot avoid hesitating to accept it as an actual occurrence. It is certainly at most a very rare, and probably secondary, modification of segmentation. It does not occur among vertebrates.

entoderm cells depends upon the amount of yolk present. The yolk-granules are *situated*, not quite exclusively but almost so, in those parts of the ovum out of which the entodermal cells are formed. Hence, when there is a great deal of yolk, the *Anlage* of the entoderm in the ovum becomes bulky, and the entodermal cells correspondingly big, as may be seen very plainly in amphibian ova. On the other hand, when the amount of yolk is very small, as in the eggs of echinoderms, the difference in size of the two kinds of cells is very slight at the start of segmentation; but, as the cleavage process continues, the ectodermal cells, in consequence of their more rapid divisions, become markedly smaller than their entodermal fellows. The same may be said in regard to mammalian ova, the segmentation of which is described more fully below. Besides its effect upon the volume of the entoderm, the yolk matter seems to actually retard the development of the inner germ-layer, by impeding the division of cells. This effect was pointed out many years ago, and is one of the familiar principles of embryology.* This is well exemplified in the bird's egg, in which the nuclei divide in the entoderm, but only gradually gather distinct cell-bodies about themselves, and in consequence the ventral side of the primitive entodermic cavity is bounded by a mass of protoplasm with scattered nuclei and numerous yolk-granules; and as these last are transformed into protoplasm, the cells are completed as separate individualities. The proliferation of the nuclei without *pari passu* separation of the cells occurs in similar manner in elasmobranchs, and comparable phenomena occur in many invertebrates, notably among the arthropods (Fig. 3437), with the so-called superficial segmentation.

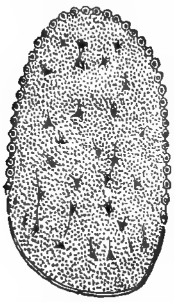

FIG. 3437.—Section of the Egg of a Moth. (After Bobretzky.) Nuclei are seen scattered through the yolk.

The terms *holoblastic* and *meroblastic* are applied to ova according to their manner of segmentation. The first is employed for those ova in which there is either very little or only a moderate amount of yolk, so that the whole of the ovum splits up into distinct masses (cells), which enter into the composition of the embryo. The second designates ova with a very large amount of yolk, so that while the protoplasm from which the ectoderm arises divides rapidly into distinct cells, the entodermal portion merely develops nuclei at first, with the result that while one portion of the egg is "segmenting," another portion (the entodermal) remains unsegmented, so far as the external appearances are concerned. Eggs, then, with much yolk undergo the so-called partial segmentation; hence the adjective *meroblastic.*

The result of segmentation is to produce two kinds of cells, ectodermal and entodermal; the latter are the larger and contain most of the yolk-granules; the entodermal cells may be represented for a certain period, partly or wholly, by a mass of yolk with scattered nuclei (Fig. 3437). The cells are arranged so as to form, each kind, a layer of epithelium. The two epithelia are joined at their edges; the line of junction is the *ectental line.* (See Fœtus.) Between the two layers, ectoderm and entoderm, is a space known as the *segmentation cavity*, and which varies in form and size according to the species of ovum. Among radiates it approaches a spherical shape, and the two epithelia make a hollow sphere; this arrangement is known as the *Blastula* form, and by some writers has been considered the primitive type of structure resulting from segmentation. In other cases the segmentation cavity is a mere slit between the entoderm distended with yolk and the ectoderm. (See the figures in the article on the Blastoderm.) Ultimately, the segmentation cavity is invaded by cells, which enter into the composition of the mesoderm (see Germ-layers, Gastrula, and Fœtus, development of), and by which the cavity is ultimately filled up. The body cavity arises subsequently in the mesoderm. (See Cœlom.) The segmentation cavity is very much reduced in amniote ova, and in birds is obliterated so early by the precocious thickening of the ectoderm that it scarcely can be said to appear.

The best-known example of a meroblastic ovum is the hen's egg. Its segmentation commences while it is passing through the lower part of the oviduct, and shortly before the shell has begun to be formed.

Viewed from above, a furrow is seen to make its appearance, running across the germinal disk, though not for its whole breadth, and dividing it into two halves; this furrow is developed in accompaniment with the division of the first segmentation nucleus. The primary furrow is succeeded by a second, nearly at right angles to itself. The surface thus becomes divided into four segments or quadrants (Fig. 3438, A), which are not at first separated

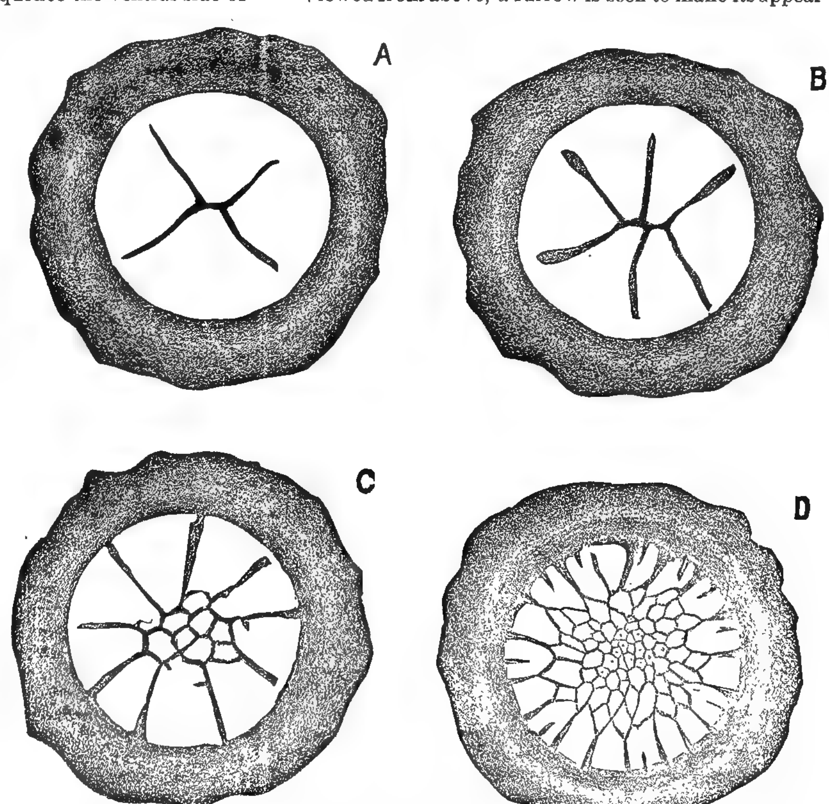

FIG. 3438.—Four Stages of the Segmentation of the Hen's Ovum. Only the germinal disk, seen from above, and part of the surrounding yellow yolk are represented. (After Coste.)

* It is not a little curious that two embryologists have recently discussed this principle as if it were quite a new discovery of their own.

from the underlying substance. The number of radiating furrows, of which there are now four, increases to from seven to nine, when there occur a series of cross-furrows by which the central portion of each segment is cut off from the peripheral portion, giving rise to the appearance of a number of small central segments surrounded by more external elongated segments. Division of the segments now proceeds rapidly by means of furrows running in various directions. Not only are the small central segments divided into still smaller ones (Fig. 3438, D), but also their number is increased by the addition of more segments cut off from the peripheral ones. Sections of the hardened blastoderm show that segmentation is not confined to the surface, but extends through the mass, there being also horizontal furrows, *i.e.*, furrows parallel to the surface of the ovum. According to Duval,[15] whose account of the segmenting hen's ovum is, on the whole, the most satisfactory, when quite a small number of cells are separated off there is a small space between them and the yolk, as shown in his Figs. 2, 3, 4, 5, and 6 of Pl. I.; this space he calls the segmentation cavity; but this can hardly be, as the cells formed below it make part of the ectoderm (primitive blastoderm); the cells referred to are those marked *in* in Fig. 8 of the same plate; the space there lettered *cg* is the entodermal cavity. We can now speak of the primitive blastoderm (compare the article Blastoderm, vol. i., p. 528). The several-layered mass of cells represents the ectoderm; it has only traces of the segmentation cavity. The yolk represents the entoderm. At this stage the ectoderm is not completely separated off, but still receives peripheral accretions from what may be called the segmenting zone around the blastoderm. For the further history see Blastoderm, and the first section of the article Fœtus, where the differentiation of the cellular entoderm is described.

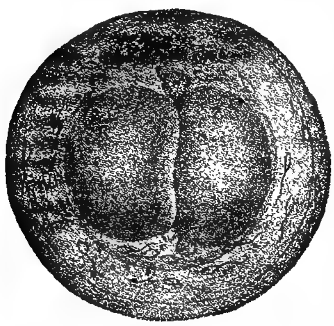

Fig. 3439.—Ovum of a Rabbit of Twenty-four Hours; the first cleavage has been completed. (After Coste.)

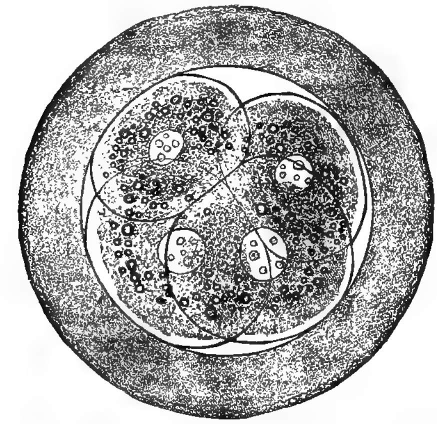

Fig. 3440.—Ovum of Vespertilio Murina, with Four Cleavage Spheres. (After Van Beneden and Julin.)

The ovum of the placental mammalia is called holoblastic, because it contains very little yolk and undergoes "total" segmentation. Its segmentation was first clearly recognized by Bischoff, though it had been previously seen and misinterpreted by Barry.[2] Very beautiful figures are given by Coste.[14] A number of more recent writers have dealt with the subject, among whom Hensen[17] deserves especial mention. Reference may also be made to Heape's observations on the mole;[16] to Kupffer's on rodents; to Selenka's on rodents and the opossum in his "Embryologische Studien;" to Van Beneden and Julin's on bats,[6] and to Van Beneden's on the rabbit;[3, 4] but of these last the entire accuracy may be doubted. The ovum is discharged from the ovary surrounded by the so-called *corona radiata*, which is composed of cells of the *discus proligerus*. It passes quite rapidly through the first half or two-thirds of the oviduct, and during this period is impregnated and loses the *corona radiata*. In the lower half, or third, of the oviduct segmentation begins, and may be wholly or only partially completed when the ovum passes into the uterus. The ovum spends about seventy hours in the oviduct in the rabbit, and about eight days in the dog. The first cleavage plane passes through the axis of extrusion of the polar globules (Fig. 3439); the two segmentation spheres flatten out against one another. The second cleavage plane is probably also meridional, as is indicated by Selenka's observations on the opossum; and there are four equivalent cells as the result. Van Beneden asserts, however, that the cells are unlike, two being smaller than the others (Fig. 3440). These smaller cells he regards as the representatives of the ectoderm. The successive cleavages have never been followed accurately, but after a time there appear an outer layer of cells (Fig. 3441), *Ec.*, forming an epithelium under the zona pellucida, *Z*, and an inner mass of cells, *im.*, of darker appearance, which at first completely fill the space within the epithelium. During all these early stages the cells (segmentation spheres) are all naked, *i.e.*, without any membrane: the nuclei, when not in karyokinetic stages, are large, clear, and vesicular; the yolk granules are small, highly refractile, and more or less nearly spherical; they show a marked tendency to lie in the egg, half-way between the nucleus and zona, or, when the cells are large, around the nucleus, but a little distance from it. The outer layer of cells is not complete, but interrupted at one point, where the inner mass (Fig. 3441, *im.*) comes through to the surface. By the continued division of the cells of the subzonal layer, that membrane forms a larger vesicle, and there arises a space between the outer epithelium and the inner mass, as shown in Fig. 421, Vol. I. The cavity, I think, is probably the true segmentation cavity; the outer layer is the entoderm, and not the ectoderm, as commonly described; and the inner mass is the true ectoderm. For the reasons of this interpretation see Blastoderm.

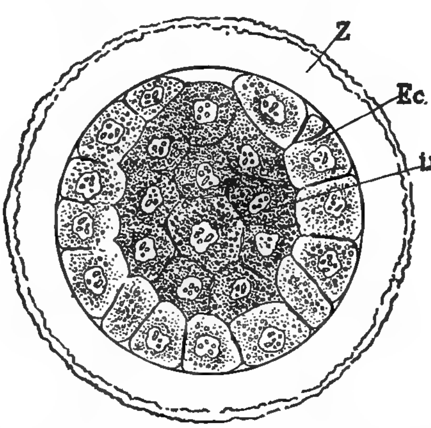

Fig. 3441.—Rabbit's Ovum in an Advanced Stage of Segmentation. *Z*, zona pellucida; *Ec.*, ectoderm of authors; *im.*, inner mass of cells.

Literature.

The literature upon Segmentation is very extensive. I cite a few of the principal articles, giving the majority of those which deal with the mammalia. There is no research published on mammalian segmentation which meets the present requirements of embryology.

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Charles Sedgwick Minot.

SELTERS is a village in the province of Hesse-Nassau, Prussia, near which is a spring which is the source of the well-known Selters or Seltzer-water. The following is the composition of this water. In one thousand parts of water there are:

Sodium bicarbonate	1.021
Calcium bicarbonate	0.550
Magnesium bicarbonate	0.210
Ferrous bicarbonate	0.030
Sodium sulphate	0.150
Sodium phosphate	0.040
Sodium chloride	2.040
Potassium chloride	0.001
Silica and aluminium	0.050
Total	4.092

Selters-water is exported in large quantities, very little use being made of it at the spring itself. It is recommended in the treatment of dyspepsia and catarrhal troubles of the respiratory organs. Its chief employment, however, is as a beverage. *T. L. S.*

SELTZER SPRINGS. *Location and Post-office,* Mendocino County, Cal.

ACCESS.—By San Francisco & North Pacific Railroad to Cloverdale; thence by stage.

ANALYSIS (H. G. Hanks).—One pint contains (61° Fahr.):

	Grains.
Carbonate of soda	7.598
Carbonate of magnesia	10.118
Carbonate of lime	1.938
Carbonate of iron	0.567
Chloride of sodium	1.478
Alumina	0.075
Silica	0.729
Total	22.503
Gas.	Cub. in
Carbonic acid	45

G. B. F.

SEMINAL INCONTINENCE. DEFINITION.—By this is meant the involuntary loss of seminal fluid, whether one is asleep or awake, by ejaculations or passive flow. The term *spermatorrhœa* has commonly been applied to this condition, but not with uniform significance. By some writers this word is made to signify only the passive flow of semen, according to its etymology (σπέρμα, semen, and ῥέω, I flow); and losses accompanying erections, spasmodic ejaculations, and orgasms, are styled pollutions. Some make a distinction between nocturnal and diurnal pollutions, or those in sleeping and waking hours, and so have three forms of the malady. Those who apply the term spermatorrhœa to all forms of seminal incontinence, speak of *true* and *false* spermatorrhœa, but here the distinction is not uniform. With some the *true* variety means emissions with erection and orgasm, while others restrict its use to cases in which the emissions contain spermatozoa. This last distinction is lacking in both precision and convenience, for the presence of spermatozoa must be determined by microscopical examination, and in the same case they may at one time be present, and at another time absent, according to frequency of emissions. In this article *seminal incontinence* will express all forms of involuntary seminal emission; the word *spermatorrhœa* will be restricted to that form in which erection, spasmodic ejaculation, and orgasm are absent; and other forms will be styled *nocturnal* and *diurnal pollutions*, according as they occur in sleeping or in waking hours.

NATURAL HISTORY.—It is to be premised that seminal incontinence may be physiological or pathological. Most men in vigorous health, who do not indulge in sexual intercourse, have occasional nocturnal emissions, and they may occur once in two weeks, once a week, or even oftener, without any impairment to health. It is only when they are followed by a sense of muscular exhaustion, pain in the head and back, mental hebetude, and depression of spirits, that they become morbid and require measures for their arrest. In health the testicles, prostate gland, and seminal vesicles are in the constant exercise of their functions, from the period of puberty to the decay of old age, and their secretions are commonly redundant, that is to say, more than the absorbents can take up and carry off in the general circulation. This redundancy is relieved by a due amount of sexual intercourse, or by occasional involuntary emissions. Excessive stimulation and use of these organs result in seminal incontinence, and later in impotence. It is unnecessary to repeat here what is described in other articles about the anatomy of the male sexual organs and their functions.

Most cases of morbid seminal incontinence begin with nocturnal pollutions, which become more and more frequent unless the exciting causes be discontinued. In neglected cases the malady is aggravated, gradually the pollutions become more frequent, they begin to occur in waking hours from indulgence in libidinous thoughts, from the friction of the clothing, especially in horseback-riding, from toying with women, from perusal of indecent books or pictures, and frequently during defæcation and urination. The erections and orgasm diminish, until the complaint runs into the third stage, when they cease,

and the flow is passive, sometimes intermittent and sometimes constant. There are instances, however, in which the emissions are passive from the beginning, but these result from gonorrhœa and are exceptional. As the pollutions become more frequent, they contain fewer spermatozoa, which are immature, have little or no motion, and finally are absent. In consequence of catarrh of the prostate gland and seminal vesicles the spermatic fluid loses viscidity and becomes watery. In some cases digestion is much impaired and the bowels become constipated. In an advanced stage the moral depression is the most serious feature; for the unhappy subject is usually ashamed to seek relief, as he would in ordinary complaints, and is apt to fall into the hands of those rapacious quacks who hire the services of a venal press to promote their nefarious business of exciting groundless fears and delusive hopes, by which victims are attracted to their toils, to be plucked without mercy.

An analysis of 175 cases by Professor S. W. Gross, M.D.,[1] shows the relative frequency of a large number of symptoms, as follows: Anxious and depressed condition of mind, 72; constant dwelling on sexual matters, 72; hypochondria, 14; mental dejection after intercourse or emission, 60; impairment of memory, 55; incapacity for prolonged mental exertion, 68; headache, 69; vertigo, 30; broken sleep, 15; insomnia, 6; drowsiness, 11; irascibility, 2; asthenopia or muscæ volitantes, 31; noises in the ears, 26; muscular weakness of the limbs and fatigue, 118; trembling of the limbs, 10; temporary reflex paraplegia, 1; pain in the back, 95; oppressed breathing, 7; pain in the chest, 3; constipation, 61; dyspepsia, 40; palpitation of the heart, 26; subjective sensation of cold, 11; and of heat, 4; loss of flesh, 9; pallor of the face, 15; feebleness of erection, with premature ejaculation, 38; irritable weakness, 29; total failure of erection, 10; elongation of the prepuce, 29; relaxation of the scrotum, 19; irritable testis, 9; varicocele, 6; hæmorrhoids, 5; coldness of genitalia, 8; sensation of heat in genitalia, 3; painful ejaculation on intercourse, 3; bloody ejaculation, 1; irritability of the bladder, 8.

As the emissions become more frequent, the erection and the orgasm are less pronounced, and the ejaculation is premature. There is pain in the head and back, with muscular fatigue and indisposition for mental effort. Then follow vertigo, loss of memory, depression of spirits, aversion to company, especially that of females, asthenopia, trembling, palpitation, shortness of breath, indigestion, and constipation. Finally there result impotence, hypochondria, insomnia, neuralgia, cold extremities, and a peculiar expression of shame. This is the usual course in neglected or ill-managed cases.

Morbid Anatomy and Pathology.—In the early stage of seminal incontinence there is preternatural irritability of the ejaculatory muscles and of the ducts of the seminal vesicles, together with excessive sensibility of this part of the urethra from undue excitation. As the case progresses the canal becomes inflamed and its walls are thickened, with narrowing of its calibre, particularly in the prostatic portion and near the meatus. Of 153 masturbators who became subjects of seminal incontinence, Professor S. W. Gross found that 127 had one or more strictures, of rather moderate narrowing in most instances, and 22 other cases not traced to masturbation all had stricture, with a single exception. Hyperæsthesia of the urethra existed in all but 11 cases. In an advanced stage the ducts of the seminal vesicles are enlarged and lose their sensibility. Inflammation of the epididymis, or of the seminal vesicles, may occur, and in the latter case is accompanied with painful purulent or bloody emissions.

Etiology.—In a large number of instances a neurotic temperament may be regarded as a predisposing cause, and this view will be confirmed by the discovery of other neuroses in the same subject, or among his near relatives. It might be more correct to say that this temperament induces the habit of masturbation. Undoubtedly ascarides, or a long and narrow prepuce, with a mass of imprisoned smegma and an irritable and herpetic glans penis, will lead to early masturbation. Habitual constipation, piles, fissures, and pruritus ani have the same effect in later years. Inquiry into the previous history will show that a considerable number have been subjects of nocturnal incontinence of urine in early childhood. Indulgence in erotic thoughts, and perusal of lascivious books, also lead directly or indirectly to seminal incontinence. The concurrence of seminal emissions with tabes dorsalis is explained by the diminished inhibitory control of the spinal cord in the functions over which it presides. Its occasional concurrence in the early stage of pulmonary phthisis, in variola, typhus fever, and chronic alcoholism, is probably to be accounted for on the same ground, but the connection is less apparent.

In the 175 cases analyzed by S. W. Gross, the exciting cause was found to be masturbation, 153 times; gonorrhœa, 7 times; masturbation and gonorrhœa, 11 times; toying with women, 1; cause obscure, 3 times. It was attributed to inherited predisposition once only. In the same list 154 were unmarried, 18 married, and 3 were widowers. Twenty-two occurred under twenty years of age; 103 between twenty and thirty years of age; 36 between thirty and forty years of age; and 14 between forty and fifty-four years of age. All the married men indulged excessively in sexual intercourse.

Diagnosis.—Whenever the emissions take place with erection and orgasm, there can be no question that they are seminal. In cases which have begun in this way the presumption is strong to the same effect. The detection of spermatozoa requires a microscopic power of four hundred diameters, but they may be absent in chronic and aggravated cases of seminal incontinence. With a history of gonorrhœa rather than of masturbation, and with emissions without erection or orgasm from the beginning, diagnosis of gleet or prostatorrhœa would be presumptive, to be confirmed by absence of spermatozoa.

Prognosis is favorable in cases which have not advanced to protracted impotence, and are not attended with profound hypochondria. A neurotic diathesis and chronic inflammation of the seminal vesicles are serious conditions. Seminal incontinence resulting from gonorrhœa or sexual excesses is more amenable to treatment than when arising from masturbation. The worst effects of the latter result from early indulgence in the habit. It is necessary in any case that the patient should be thoroughly obedient and tractable, and persevere with treatment uninterruptedly.

Treatment.—An indispensable condition to recovery is removal or discontinuance of all the etiological factors, and here is the great difficulty. Masturbation and sexual intercourse must be prohibited; erotic thoughts and whatever might suggest them must be banished; stimulating food and drinks must be eschewed; the bladder should be emptied before the hour of rest, and once or more times during the night; the bed should be rather hard, and the cover barely sufficient for comfort; the dorsal decubitus should always be avoided; both mind and body should be sufficiently occupied to prevent dwelling upon the complaint and indulging in any of its causes. A close inspection must be made of the external genitals and anus for sources of irritation. A redundant prepuce calls for circumcision. Herpes of the glans or prepuce may be relieved by the application of dry calomel or a weak solution of lunar caustic. Stricture of the urethra requires dilatation or division, and it must not be allowed to contract again. The hyperæsthesia of the canal in the early stage is best overcome by the passage of a steel sound, as large as it will admit, two or three times a week, remaining from five to twenty minutes. In case of excessive irritability its sensibility may be obtunded, prior to the introduction of the sound, by the injection of a solution of cocaine. In some cases an exquisitely sensitive, inflamed tract may be found in the prostatic portion by exploration with an acorn-pointed bougie. This having been accurately located, is best treated by a local application of lunar caustic solution, ten to thirty grains to the ounce, by a catheter syringe; or by projecting from a *porte-remède* a small quantity of cocoa butter, incorporated with about one-eighth of a grain of silver nitrate. A short frænum should be divided. External

piles may be injected with carbolic acid, and internal piles be removed by the ligature or the *écraseur*. Pruritus may be relieved by a lotion of corrosive sublimate, two or three grains to the ounce, or a five per cent. solution of carbolic acid. Constipation may be relieved by a pill containing resin. podophylli, gr. $\frac{1}{8}$; extract. bellladon., gr. $\frac{1}{4}$; extr. nucis vom., gr. $\frac{1}{4}$; pulv. aloes, gr. iij., taken at first every night, and then every other night, till the habit is overcome.

Internal medication for this malady must be adapted to the stage and the symptoms. In the stage of nocturnal pollutions the object is to diminish the excitability of the nervous tract which presides over the genitalia. The bromide of potassium and atropine are the agents of greatest value. Twenty to thirty grains of the former may be given three times a day, and one-sixtieth of a grain of the latter at bedtime. If the patient be weak and anæmic, it is preferable to give quinine and iron during the day, and sixty grains of the bromide with the atropine at night. In case of diurnal pollutions, a similar medication is appropriate. In the stage of spermatorrhœa, when the spermatic ducts are relaxed and there is atony of the ejaculatory muscles, a combination of ergot and strychnine will be found useful, say one-half drachm of the fluid extract of the former with one-twentieth grain of the latter, after meals, three times a day; or, in an anæmic condition, twenty drops of the muriated tincture of iron with five drops of the tincture of cantharides. These remedies may be supplemented by the constant galvanic current, with the positive rheophore on the perineum and the negative in the rectum, commencing with an application for two or three minutes and gradually increasing the duration, according to toleration. The strength of the current, at the beginning, should be such as the operator can pass through his own temporal region.

Abstinence from sexual indulgence and from all excitement of the organs must be enforced until the anatomical lesions are entirely healed and the functional derangement has ceased. Subsequent moderation is to be enjoined with the married, and the unmarried, if their circumstances warrant, may then be counselled to essay matrimony. *S. S. Herrick.*

[1] Disorders of the Male Sexual Organs.

SENEGA, U. S. Ph. (*Senegæ Radix*, Br. Ph.; *Radix Senegæ*, Ph. G.; *Polygale de Virginie*, Codex Med.). The root of *Polygala Senega* Linn., order *Polygalaceæ*. A delicate-looking perennial herb, with a rather thick, knotty, somewhat branched crown, from which numerous slender, wiry, generally simple, smooth, upright stems, twenty or thirty centimetres long arise, and one or two rather stout, crooked, branching woody roots descend; leaves lanceolate, two or three centimetres long, alternate, smooth. Flowers small, pinkish-white, in terminal spikes. Calyx irregular, of three small green, and two (lateral) large, petaloid sepals, the latter concave and inclosing the corolla. This consists of three partly united petals, of which the lower is concave and ornamented with a crest of papillæ. Stamens eight, diadelphous (4 × 4). Ovary transversely two-celled. Style single. Senega has a wide range in the United States from western New England and the Middle and Western States southward. It is now mostly collected in the West and South. *P. S. latifolia* is a larger form with broader leaves.

The plant takes its common name, Seneca Snakeroot, from the Seneca Indians, by whom it is reported to have been used as a remedy for snake-bites. It was introduced into modern medicine by Dr. Tennent, of Virginia, about 1734, for pleurisy and pneumonia (Flückiger), and has had times since then of very great popularity.

The root is about four inches (10 centimetres) long, with a very knotty crown, and spreading, tortuous branches, keeled when dry, fleshy and round after having been soaked in water; externally yellowish-gray, or brownish-yellow; bark thick, whitish within, inclosing an irregular, porous, yellowish wood; odor slight but unpleasant; taste sweetish, afterward acrid. The woody column of Senega root is very irregular; near the crown it is cylindrical, but lower down markedly excentric, semicylindrical, or with wide vacant gaps, or clefts, of parenchymatous tissue.

Composition.—The special interest of Senega lies in the substance originally called *Senegin*, later *polygalic acid*, and by some considered to be the same as saponin, to which it is undoubtedly related. It is amorphous, soluble in water, making a frothy solution; it is also sternutatory. It is, moreover, a glucoside, separable into *sapogenin* and sugar. The yield is about two per cent. *Oil*,

Fig. 3442.—Senega, Root and Stems. One-half natural size. (Baillon.)

resin, *gum*, and other unimportant matters are also found in it.

Action and Use.—Senega in large doses is an irritant and nauseating emetic, also a purgative; in medicinal ones it is reputed to be a stimulating expectorant. It has been extensively employed in chronic bronchitis and other diseases accompanied by cough. As an ingredient of cough preparations it has probably its most extensive use, but is much less valued than formerly; as an emmenagogue and diuretic it is obsolete.

Administration.—Dose of Senega is about one gram (1 Gm. = gr. xv.). The preparations are Abstract (*Ab-*

stractum Senegæ, U. S. Ph.), strength $\frac{2}{1}$, and the Fluid Extract (*Extractum Senegæ Fluidum*, U. S. Ph.). It is also in the Compound Syrup of Squills (*Syrupus Scillæ Compositum*, U. S. Ph.).

ALLIED PLANTS.—See RHATANY. *W. P. Bolles.*

SENILITY. In old age there normally occur certain changes in the tissues, and, as sequelæ, anatomical and physiological alterations of the senescent body. The changes are principally atrophic and degenerative.

Senile atrophy involves especially the muscles and glands, but also affects other soft parts. The cellular elements diminish in size progressively, but without apparently presenting any essential modification in their structure. Thus the muscular fibres become small, and, it is said, more uniform in size; the spleen and lymphatic glands undergo a remarkable diminution in volume and weight, which increases with the advance of age. In the digestive tract the glandular parts and villi are somewhat shrunken. Where there has been an accumulation of fat, it gradually wastes away.

Senile degeneration begins somewhat later than the atrophy. The elements become the seat of fatty or pigmentary infiltrations, or calcareous incrustations. The fatty degeneration occurs, for instance, in the striped muscle-fibres, both the voluntary and cardiac; in the smooth muscles; in the blood-vessels, especially in the cerebral arterioles, and probably also in the nerve-cells and the parenchyma of glandular organs. The pigmentary infiltrations are much rarer. Calcareous deposits occur, especially in the tendons, ligaments, and cartilages, also in the pineal gland. In the central nervous system the neuroglia tends to predominate over the nervous elements proper, and tends to become permeated by a greater or less number of amylaceous bodies; the tissue of the brain undergoes a chemical change—the fatty constituents are diminished, while the amounts of water and phosphorus are increased.

In consequence of these changes the weight and height of the body as a whole is lessened, and the size of most of its parts is lessened also; this holds true of the muscles, skeletal structures, brain, spinal cord, nerve-trunks, lungs, liver, spleen, etc.; but it does not apply to the heart or kidneys, the heart being often hypertrophied and the kidneys retaining the size of middle life. The skin becomes dry and wrinkled, the hair scanty and white, the gums toothless, the body crooked and sunken.

Physiologically there is a general impairment of the vigor, resulting from the atrophy and degeneration. There is great muscular enfeeblement; the amount of carbonic acid exhaled is diminished, as is also the vital capacity of the lungs; but, on the other hand, the respiratory rhythm is quickened. The secretions are diminished. There is less urine. The rate of the heart-beats rises.

Such, categorically given, are the changes in old age. Unfortunately, there is no thorough and satisfactory compilation of these data, which, though very numerous, are scattered through a vast literature. Until this century old age scarcely received scientific consideration; those who wrote upon it wrote like Cicero, in his *De Senectute*, from a contemplative literary standpoint. It was not until 1839 that anything very serious from the medical side was attempted. In that year Canstatt published, at Erlangen, his treatise on the diseases of old age. Since then there have been a number of manuals of similar scope, but in none of them, so far as I know, is there to be found a thorough and comprehensive review of the normal changes in old age, although such a review is urgently needed. The preceding paragraphs follow Charcot closely. (See Tuke's translation, Sydenham Society, 1881.)

Charles Sedgwick Minot.

SENNA, U. S. Ph. (*Folia Sennæ*, Ph. G.; *Sené*, Codex Med.; *Senna Alexandrina* and *S. Indica*, Br. Ph.; Alexandria and Tinnivelly (Indian) Sennas). The leaflets of several, at present mostly of two, species of *Cassia*, order *Leguminosæ* (*Cæsalpineæ*), growing wild in Nubia, Upper Egypt and Arabia, or cultivated in Southern India. In the United States, German, and French Pharmacopœias the general term covers both the principal varieties; in the British, the Alexandrian and Tinnivelly Sennas are distinguished by name; they are always entirely distinct in the market.

The genus *Cassia* is a very large one, numbering three or four hundred species, many of which produce handsome ornamental flowers; it is also the type of a tribe (*Cassiæ*) including nine or ten other genera, of which nothing need be said from a medical point of view. *Ceratonia* (St. John's Bread) is one of them. The Cassias are herbs, shrubs, or trees, with abruptly pinnate leaves, usually showy yellow flowers in axillary or terminal racemes or panicles, and, in the section to which the above Sennas belong, extremely flat pods. The following two species supply nearly all the Senna of modern commerce.

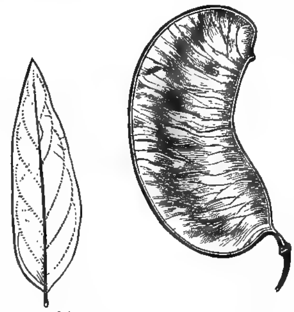

FIG. 3443.—Cassia Acutifolia, the source of Alexandria Senna, leaf and pod; about natural size. (Baillon.)

1. *C. acutifolia* Delile, is a small shrub about sixty centimetres (two feet) high, with pale, slender, round or slightly angled, branching, somewhat zigzag, smooth (at least when old) stems, alternate leaves of four or five pairs, and rather small flowers. Calyx imbricated, of five oblong, blunt sepals. Corolla subregular, of five, obovate, yellow petals, the lateral and lower ones larger than the upper. Stamens ten, the three upper abortive, the two lower lateral ones very large, the others subequal; anthers opening by terminal pores. Pistil one, a simple carpel raised upon a short stalk, and, like the longer stamens, curved upward. Pod broad, flat, coriaceous, slightly curved, rounded and oblique at the ends, containing about half a dozen seeds. This species has a wide and unknown range in Central Africa, it is abundant in Nubia, Kordofan, Sennaar, etc., and is said to be found in Timbuctoo.

2. *C. angustifolia* Vahl., is also a small shrub, a good deal like the preceding, but it has larger flowers and larger, more numerously paired leaflets. Its pod is narrower and straighter than that of *C. acutifolia*, and contains about eight seeds. It is a native of Arabia, and in the wild state supplies an inferior, carelessly collected variety of Senna (Arabian). It is also said to be found in the Somali Land. This is the species cultivated in the south of India (where it is not indigenous) as the source of Tinnivelly Senna. The leaves, under cultivation, are increased in size and improved in quality.

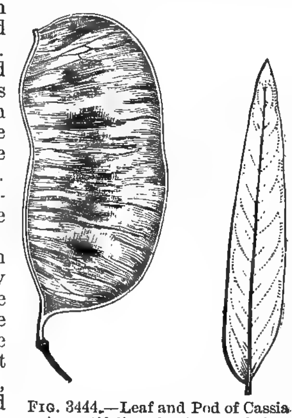

FIG. 3444.—Leaf and Pod of Cassia Angustifolia; about natural size. The leaf is Tinnivelly Senna. (Baillon.)

C. obovata Colladon, is an herbaceous or semi-shrubby perennial, of very much the same general habits as the above, but whose leaflets are broader, obovate, with blunt apex and base, the former, however, mucronate, and about two and a half centimetres long. Flowers large and handsome, much like the others, pod considerably curved. It grows over the same range as *C. acutifolia*, but also extends to West Africa and India; it has been introduced into Southern Europe, and formerly furnished the European or Italian Senna. This species formerly supplied a considerable part of the Alexandria Senna, being mixed with the leaflets of *C. acutifolia;* but at present it seldom appears

in any shape. It is of inferior quality and should be rejected.

C. brevipes of Central America, *C. Schimper* of Abyssinia, and several other species of both hemispheres, have been proposed as substitutes for Senna, but have at present no commercial existence.

Senna appears to have been introduced into European use in the ninth or tenth century; the pods were used as well as the leaves, and even preferred to them.

Collection: This, in the wild districts of Nubia and Arabia, is done in the coarsest and most primitive manner. The shrubs are cut down and exposed to the sun until the leaves are dry, when they are stripped off bringing leaf-stalks, twigs, flowers, and pods with them. They

Fig. 3445.—Cassia Obovata, the Source of an Inferior Variety of Senna. (Baillon.)

must be afterward cleaned and sorted before they are fit for use. Tinnivelly Senna is always clean.

Description.—Alexandria Senna is usually described with great care as consisting of a pretty uniform mixture of the leaflets of *C. acutifolia*, *C. obovata*, and one or two other leaves or leaflets of plants not Cassias at all (*Solenostemma Argel* Hayne, order *Asclepiadaceæ*, *Tephrosia*, *Colutea*, *Coriaria*, etc.), but this applies only to the past, as the Senna of recent years is improved in quality and appearance, and consists almost entirely of the leaflets of the desirable *C. acutifolia*, with stems and pods of the same. The following is the officinal description: "Alexandrian Senna consists of leaflets about one inch (twenty-five millimetres) long, lanceolate or lanceoval, subcoriaceous, brittle, rather pointed, unequally oblique at the base, entire, grayish-green, nearly smooth, of a peculiar odor, and a nauseous, bitter taste. It should be freed from stalks and from argel leaves (the leaves of *Solenostemma Argel* Hayne), which are frequently present; these leaves are thicker, one-veined, glaucous, and even at the base. India Senna consists of leaflets nearly two inches (five centimetres) long, acute, unequally oblique at the base, entire, dull green, slightly pubescent, of a peculiar odor and a mucilaginous, bitter taste. It should be freed from stalks, discolored leaves, and other admixtures." The leaves of Alexandria Senna are always considerably broken, those of Tinnivelly generally whole. The former commands the higher price; there appears to be no medicinal difference between them. Besides these two varieties there is Arabian, often called "Indian," Senna, because imported through Indian ports, whose leaves have the same shape, etc., described above as Indian Senna, but are smaller. It is a cheap, poor, and usually very dirty article, seldom used here. *Senna pods* form a separate article in continental shops; they have the shape, size, etc., figured above, and the same properties as the leaflets.

Composition.—*Sennacrol* and *sennapicrin* are two bitter and acrid substances, separable from senna by treatment with alcohol. The former is, the latter is not, soluble in ether. Neither of them is the valuable part of senna. This is principally found in *cathartic acid*, an uncrystallizable, dark brown, astringent-tasting substance of decidedly cathartic qualities. It is soluble in warm diluted alcohol, but is nearly insoluble in strong alcohol or water. Cathartic acid is a glucoside yielding by decomposition "*cathartogenic acid*." A coloring matter, *chrysophan*, also found in rhubarb, etc., and a sugar, *catharto-mannit*, are the remaining constituents. Cathartic acid is also found in the bark of Frangula and other *Rhamni*.

Action and Use.—This is one of the most satisfactory and generally useful of simple cathartics, usually emptying the bowels thoroughly in ten or twelve hours, with but little depression or other untoward effects, excepting a variable amount of griping; it acts principally upon the small intestine, and the amount of effect produced can generally be pretty accurately regulated, by the dose, from the mildest laxative to a brisk cathartic. It is in universal domestic use, and is the foundation of numerous proprietary laxatives. By combination with salines its activity is considerably augmented; in small doses it does not readily lose its efficiency. It appears to be partially excreted in the milk, when taken by nursing women.

Administration.—A few Senna leaves chewed every day are a favorite habitual laxative with many people, who find them to act efficiently, without griping and without producing after-sluggishness of the bowels. One or two dozen leaves usually display some effect. In large doses (six or eight grams [ʒ jss.] or more), as required for thorough action, it is apt to produce colic, unless modified by aromatics or salines. A strong alcoholic extract is inert; a watery extract, made from the residue after exhausting by alcohol, is active and much pleasanter than one made without this previous treatment. Infusion with hot water extracts the active principle (salts of cathartic acid), and makes a good form for administration, but prolonged boiling destroys it, as do also mineral acids and alkalies, by decomposing the cathartic acid. Bitters are said to increase its action.

The officinal preparations are numerous and good. The Fluid Extract (*Extractum Sennæ Fluidum*, U. S. Ph.), made with weak alcohol, represents the leaves weight for weight. It is not often given alone, but is eligible for mixture with other medicines. The Compound Infusion, Black Draught (*Infusum Sennæ Compositum*, U. S. Ph.), consists of:

Senna, 6 parts.
Manna, 12 parts.
Sulphate of Magnesium, 12 parts.
Fennel, bruised, 2 parts.
Boiling water, 100 parts.

Macerate and strain; then add water to make 100 parts. It is six per cent. senna, and twelve each of manna and Epsom salts. The Syrup (*Syrupus Sennæ*, U. S. Ph.) consists of 33 parts of senna with a little oil of coriander. The Compound Licorice Powder (*Pulvis Glycyrrhizæ Composita*) is one of the most extensively used laxatives; it is composed as follows:

Senna, 18 parts.
Licorice, 16 parts.
Fennel, 8 parts.
Washed sulphur, 8 parts.
Sugar, 50 parts.

The ingredients should be finely powdered and thoroughly mixed. One of the most elegant preparations in

the Pharmacopœia is the Confection of Senna (*Confectio Sennæ*, U. S. Ph.):

Senna, 10 parts.
Coriander, 6 parts.
Cassia fistula, 16 parts.
Tamarind, 10 parts.
Prune, 7 parts.
Fig, 12 parts.
Sugar, 50 parts.
Water, 60 parts.

It is a black extractiform mass, of pilular consistency, with a mawkish, but not disagreeable, sweet taste. Confection of senna is an appropriate remedy for chronic constipation, and is especially useful in the case of children, who will often take it as a candy. The Compound Syrup of Sarsaparilla contains twelve parts of Senna in a thousand.

ALLIED PLANTS.—Of the three hundred or more *Cassias* but few have medical importance, although many are probably cathartic. *C. marilandica* Linn., a perennial herb of the United States, is a moderately active, safe cathartic in somewhat larger doses than the Eastern Sennas; the leaves, stems, and flowers are usually collected together. *C. fistula* Linn. (see CASSIA, PURGING), a large East Indian tree, with striking cylindrical fruits half a metre long, is a mild laxative, used in the composition of Confection of Senna. The order *Leguminosæ* is one of the largest in the botanical kingdom, and includes numerous very interesting, useful, and beautiful plants, as the following partial list will show:

Baptisia tinctoria, our yellow False Indigo.
Lupinus, *Laburnums*, ornamental flowers.
Genista, Dyer's Woad.
Cytisus Scoparius Link, Broom Tops.
Trigonella Fœnum græcum Linn., Fenugreek.
Melilotus, Sweet Clovers.
Trifolium, Clovers.
Indigofera tinctoria, Indigo.
Wistaria sinensis, Wistaria.
Robinia, Locusts, etc.
Astragalus, sp. var. Tragacanth.
Glycyrrhiza glabra Linn., Licorice.
Arachis hypogea Linn., Peanuts.
Vicia, *Lens*, *Pisum*, etc., Peas, lentils, etc.
Abrus precatorius Linn.
Mucuna pruriens D. C., Cowhage.
Butea frondosa, a source of kino.
Physostigma venenosum Balfour, Calabar Bean.
Phaseolus, sp. var. Garden Beans.
Pterocarpus Marsupium Roxb., Kino.
Pterocarpus Santalinus Linn., f. Red Saunders.
Piscidia erythrina, Jamaica Dogwood.
Myroxylon Toluifera H. B. K., Balsam of Tolu.
Myroxylon Pereiræ Klotzsch, Balsam of Peru.
Hæmatoxylon Campechianum Linn., Logwood.
Cassia, sp. var. Senna, etc., Purging Cassia.
Ceratonia siliqua, St. John's Bread.
Tamarindus Indica Linn., Tamarinds.
Copaifera, sp. var. Copaiba.
Acacia, sp. var. Gum Arabic, Catechu; and many others of the most diverse properties.

ALLIED DRUGS.—The nearest related cathartics to Senna are probably the *Rhamni* and Rhubarb. See also Aloes, Jalap, etc. *W. P. Bolles.*

SENSATION, DISORDERS OF. The disorders of the special senses will be found discussed under the diseases of the organs to which they refer. We shall here discuss the other modes of sensation and their pathological relations, beginning with cutaneous sensibility.

All the different modalities of sensation may be affected, either singly or in various combinations, as the result of morbid processes occurring in the terminations of the sensory fibres in the integument, in their course from the periphery along the nerve-trunks, or at their central origin in the brain and spinal cord. In the majority of cases we are able to determine the site of the lesion by the sensory disturbances themselves, or by the associated symptoms.

Cutaneous sensibility includes tactile sensibility in the general sense, and common sensations. The former includes the sense of touch, the sense of location, the sense of pressure, and the sense of temperature. At the present time these different sensory qualities are commonly supposed to be inherent in different kinds of nerve terminations and fibres, but the discussion of this question must be left to the physiologist.

The common sensations include the sense of pain, pruritus, tickling, sexual feeling, and electro-cutaneous sensibility.

The sense of touch is tested by applying different objects gently to the skin, the patient's eyes being kept closed during the experiment. He is then asked to state whether he has felt anything or not, and to describe the surface of the object (sharp, blunt, rough, smooth) which is brought in contact with the skin. In ordinary examinations it is sufficient to use the head and point of a pin, the tip of one of the fingers, or the point of a lead-pencil. This should be applied gently, in order to avoid producing pain and thus confusing the sensations in the mind of the patient. As in the tests for all other forms of sensibility, the experiment must be repeated over and over again; the patient must sometimes be asked as to his sensations, although nothing has been applied to the skin; and, above all, similar tests should be made on the corresponding healthy part of the integument of the opposite side of the body, or, if this is not practicable, on some other part of the body. It is also very often advisable for the physician to repeat the various tests upon himself, in order that he may be able to compare the sensations produced in himself with the statements made by the patient. There are very few points in symptomatology with regard to which the patient, and therefore the physician, are so apt to be led astray as in the tests for disorders of sensation. This is often true, even when the patient is very intelligent; but with the ignorant we are frequently compelled to abandon all hope of arriving even at the approximate truth. The results of such examinations are almost *nil* in children—except with regard to the sense of pain—because, even though they are able to speak, they are unable to analyze their sensations.

The sense of localization is tested in two ways: first, by touching the skin with any small object and then directing the patient (with closed eyes) to indicate with the finger the part of the skin which has been touched. It is also tested by determining the smallest distance at which two sharp points can be distinguished separately.

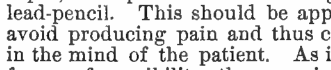

FIG. 3446.

This is done by means of an instrument known as an æsthesiometer. Sieveking's æsthesiometer (Fig. 3446) consists of a metallic rod, divided into millimetres, with two pointed arms given off at right angles to the rod. One arm is fixed to the end of the rod, the other can be moved along its whole length. Both points are applied repeatedly to the part to be tested, until we find the shortest distance (which is read off upon the scale) at which they are felt as two distinct points. The average distances at which this takes place in adults, and in a boy of twelve years, are shown in Landois' table:

	Adult. Mm.	Boy. Mm.
Tip of the tongue	1.1	1.1
Third phalanx of the finger (anterior)	2.3	1.7
Vermilion border of the lips	4.5	3.9
Second phalanx of the finger (anterior)	4.5	3.9
Third phalanx of the finger (posterior)	6.8	4.5
Tip of the nose	6.8	4.5
Head of the metacarpus (palmar)	6.8	4.5
Dorsum of the tongue White of the lips Metacarpus of the thumb	9.0	6.8
Great toe (plantar)	11.3	6.8
Second phalanx of finger (posterior)	11.3	9.0
Cheek	11.3	9.0
Eyelid	11.3	9.0
Hard palate (middle)	13.5	11.3
Malar bone (anteriorly)	15.8	11.3
Metatarsus hallucis (plantar)	15.8	9.0
First phalanx of finger (posterior)	15.8	9.0

	Adult. Mm.	Boy. Mm.
Head of metacarpus (posterior)	18.9	13.5
Inner side of lip	20.3	13.5
Malar bone (posteriorly)	22.6	15.8
Forehead (below)	22.6	18.0
Heel (posteriorly)	22.6	20.3
Occiput (below)	27.1	22.6
Dorsum of hand	31 6	22.6
Chin	33.8	22.6
Vertex	33.8	22.6
Patella	36.1	31.6
Sacrum, Gluteal region	40.6	33.8
Forearm, Leg	40.6	36.1
Dorsum of foot near the toes	40.6	36.1
Sternum	45.1	33.8
Neck (high up)	54.1	36.1
Spine (fifth dorsal vertebra, dorsal and lumbar region)	54.1	....
Neck (middle)	67.7	....
Arm, Thigh, Middle of back	67.7	31 6 to 40.6

Any marked deviation from these distances, on one side or the other, is an evidence of a morbid state. In using the æsthesiometer care must be taken that the two points are applied to the skin at the same time, and with the same degree of force (not sufficient to produce pain), and that they possess approximately the temperature of the skin. In making this test we must be especially on our guard against unintentional deception on the part of the patient, and must verify the results by repeated "control" tests.

Fig. 3447.

The sense of pressure is tested by applying, successively, different weights to the part examined, the latter being firmly supported in order to exclude the muscular sense. Eulenburg constructed a baræsthesiometer for the purpose of testing this sense. It consists (Fig. 3447) of a rod connected with a spring, and a dial-plate, upon which is registered the amount of force exerted by the rod, that is brought in contact with the skin. Eulenburg found, with the aid of this instrument, that the following increments of pressure could be appreciated on the different parts of the body:

Forehead, Lips, Dorsum of the tongue, Cheeks, Temples	$^1/_{40}$–$^1/_{30}$	Phalanges of the fingers, Forearm, Hand, Arm	$^1/_{20}$–$^1/_{10}$

Goltz devised an apparatus for the determination of the minimum amount of pressure which could be appreciated. It consists of a rubber tube, which is brought in contact with the integument, and through which waves of fluid of a known amount of force are passed.

A simple test consists in placing a coin or other weight upon the skin, and then adding others until the patient appreciates the increase. The proportion between the original weight and the added weight necessary to produce an appreciable difference, is the minimum appreciable increment.

The sense of temperature may be tested by Eulenburg's thermæsthesiometer. This consists simply of a transverse rod, to which are fastened two surface thermometers. The latter are heated to different degrees, and applied to the skin. We then note the minimum difference between the two thermometers which can be appreciated by the patient. Eulenburg found that this sense was most acute between 27° and 33° C. (80.6° and 91.4° F.). Upon the arms the minimum appreciable difference of temperature was found to be 0.2°; on the cheeks, 0.2° to 0.4°; on the temples, 0.3° to 0.4°; on the back of the hand, 0.3°; on the palm of the hand and dorsum of the foot, 0.4°; on the leg, 0.5° to 0.6° C.

A coarser method of testing the temperature sense is the application to the skin of test-tubes containing water at different degrees of heat, or placing the part alternately in warm and cold water, and noting whether the patient is able to detect the difference. When employing the latter methods we should always make the same experiment on ourselves.

Goldscheider comes to the conclusion, from his experiments, that there are special nerve-fibres for the perception of heat and of cold, and Herzen has reached the same conclusion from the observation of a case of myelitis, which will be referred to later on.

The sense of pain is tested by simply irritating the skin, by pricking it with the point of a pin, pinching it, etc. It must be remembered that there are very great normal variations in the sense of pain of different individuals. The results of irritation of the diseased part should always be compared with those of irritation of the corresponding normal part on the opposite side of the body, or, if this cannot be done, with some other healthy part of the integument. Bjoernstroem devised an "algesimeter," consisting of a pair of forceps between whose blades the skin is compressed to the point of production of pain. The amount of pressure is shown upon a scale attached to the instrument.

The electro-cutaneous sensibility has not hitherto seemed to possess any important practical bearings. The test may be made with regard to the minimum strength of current which will give rise to a perceptible sensation, and also the minimum strength which will be attended with a painful sensation. Erb employs the following method: One large moist electrode is placed on the sternum, and the other one on the part to be tested. This electrode consists of a hard-rubber tube containing about four hundred fine, insulated metal wires, its free end being made as smooth as possible. The cylinder of the faradic battery, with which the electrodes are connected, is withdrawn slowly, until the first minimum electrical sensation occurs, and the amount of withdrawal is noted; the cylinder is then withdrawn more rapidly, until a distinct sensation of pain is felt, and the amount of this withdrawal is again noted.

The rapidity of sensory conduction from the skin may also be interfered with. It is possible that the conduction may be accelerated, but the recognition of such a condition would require very delicate instruments for the measurement of time. So far as we know, no investigations have ever been made on this point. In numerous cases, however, there is an evident delay in the conduction of sensation, which can be determined by the unaided senses. If a healthy individual is pricked on the sole of the foot, *i.e.*, on the part whence the nerve-current has the longest distance to travel before reaching the cerebral centre, he will immediately manifest his perception of the irritation. When sensory conduction is delayed an appreciable interval—even at times as much as fifteen seconds—will elapse before the patient gives evidence by some sign that he has felt the prick. This delay in conduction may affect only certain forms of sensation, while that of other forms remains normal, and thus gives rise to a peculiar phenomenon, which will be considered later on.

Exner gives the following as the duration of the latent period in healthy individuals:

Stimulus.	Time between stimulation and perception, in fractions of a second.
Shock on left hand	0.12
" " forehead	0.13
" " toe of left foot	0.17

But when all is said, it will be found that refined tests are not practicable in the examination of disorders of sensation at the bedside. In the first place, an inordinately great amount of time would be required, so that a thorough examination of sensibility would often last many hours. But apart from this, the errors increase in proportion to the refinement and delicacy of the tests. The majority of individuals are unused to making a careful analysis of their sensations, and really remain ignorant of their own feelings, or are unable to convey an accurate idea of them in language. In many cases, fur-

thermore, the sensations experienced are unlike any that have been felt before, so that the patient is compelled to describe them by analogy. In those cases, on the other hand, in which there is a morbid habit of analyzing the various bodily sensations, we must be on our guard against unintentional exaggeration.

In my own examinations I have entirely discarded the use of special instruments, having come to the conclusion that even the simple æsthesiometer furnishes untrustworthy results in many cases.

Muscular sensibility will next engage our attention. This is best tested with the faradic current applied, preferably, to the motor points of the muscles. When the current acquires a certain strength the muscular contraction is accompanied by a peculiar, indefinable sensation, which is readily distinguished from electro-cutaneous sensibility. When a certain increased strength of current is reached, the patient experiences pain in the muscle. The limits of both sensations may vary from the normal. Some writers claim that muscular sensibility is dependent upon cutaneous irritation, but this is disproved by the fact that it may persist despite the most complete cutaneous anæsthesia. Moreover, recent investigations have demonstrated the existence of sensory fibres in the muscular tissue.

Our appreciation of the position of the limbs (without the aid of the sense of sight) depends not alone on the muscular sensibility, but also on that of the integument, joints, and fasciæ. This may be tested in the following manner: The physician places the limb, when the muscles are relaxed, in various positions—it is best to grasp the part by means of a handkerchief, in order to exclude the cutaneous sense of pressure—and then directs the patient to place the corresponding limb on the opposite side of the body, if the functions of the latter are normal, in a similar position. If there is paralysis or inco-ordination of the opposite limb, he is directed to describe the position of the limb which has been subjected to passive motion. This can be done with great accuracy in the normal condition.

By the *muscular sense* proper we are able to determine, with the eyes shut, the degree of contraction of the muscles during movement. We are thus able to determine the weight of objects by the amount of muscular force required to overcome it, and this sense is even more accurate than the cutaneous sense of pressure. It may be tested by suspending weights to the limb by means of a handkerchief looped over the part. For example, if the flexors of the forearm are to be tested, a handkerchief is tied into a loop, passed around the palm (the extensors being well supported on a firm base, so that they are not brought into play), and different weights are placed successively in the loop. We then note the smallest increment or decrement of weights which can be appreciated by the patient. In the normal condition an increment of $\frac{1}{40}$ can be appreciated by the muscular sense, while only $\frac{1}{30}$ can, on the average, be detected by the cutaneous sense of pressure. The action of the latter, however, can never be entirely excluded in these experiments. Another test consists in directing the patient, with the eyes closed, to perform certain movements, such as placing the finger on the tip of the nose, describing a circle with the foot, etc. When the muscular sense is impaired these movements cannot be performed with the normal degree of accuracy, but are done in a bungling fashion, or the patient shoots wide of the mark. In some cases the affection may be so marked that the patient is almost entirely unable to perform any movement when the eyes are closed, although he may be under the impression that the desired movement has been accomplished.

The real nature of the muscular sense is involved in great obscurity, although it has long been the subject of study by philosophers and physiologists, and is of far-reaching importance with regard to our notions of the mechanism of nerve action. Some writers believe that it is the result of centripetal impressions derived from the contracting muscles, others, that it results from a consciousness of the "out-going current" from the cortical centres at the moment of contraction; while Weir Mitchell suggests that it is produced by "the messages sent to the sensorium from the spinal ganglia, which every act of motor volition excites."

The various forms of sensation, which we have thus briefly considered, may present an abnormal exaggeration, diminution, or perversion. These deviations from the normal may result from an affection of the terminal ramifications of the sensory fibres in the integument, of the conducting paths in the nerve-trunks, spinal cord or brain, or of the sensory centres. We shall deal separately with each form of sensory aberration.

Cutaneous anæsthesia is the diminution or abolition of the function of the sensory nerves of the skin. The function of the various nerves may be affected in different degrees. For example, the sense of touch may be abolished, while the sense of temperature remains intact; or tactile sensibility may be abolished, while the sense of pain is greatly exaggerated, etc. When all forms of cutaneous sensibility are diminished or abolished, we speak of total anæsthesia; the term partial anæsthesia is used when certain modes of sensation are alone affected.

In many cases anæsthesia is also associated with diminution in the rapidity of conduction of the sensory impressions, and, as we shall see later on, this may also affect the different modes of sensation in different degrees.

Cutaneous anæsthesia, resulting from an affection of the terminations of the nerves, is observed in certain skin diseases, such as acute pityriasis rubra, certain forms of eczema, lichen, or psoriasis. It is also produced by congelation of the skin (by evaporation of ether or rhigolene, or prolonged exposure to cold), by hypodermic injections of narcotics (morphine, atropine, cocaine), or by the application of acids and alkalies. In these cases the anæsthesia usually affects all forms of sensation to an equal degree (total anæsthesia). Fournier observed patches of cutaneous anæsthesia scattered over the entire body in secondary syphilis, and it is probable that this condition is due to the direct action of the virus on the terminations of the nerves.

Anæsthesia may be produced by interference with conduction through the peripheral nerves. This may result from direct injury to the nerve (by gunshot or stab wounds, blows, etc.), from the pressure of tumors or aneurisms, neuritis, rheumatic influences, the application of cold to the course of the nerve, various forms of chronic poisoning (ergot, lead, arsenic), or diminished supply of arterial blood (embolism of an artery); and it also occurs in anæsthetic leprosy. It is a peculiar fact that in compression of a mixed nerve the sensory fibres are usually affected to a much less marked degree than the motor fibres; in fact, the former may appear to be entirely intact despite complete motor paralysis. In rare cases, on the other hand, the opposite condition is observed. I have noticed this particularly in compression of the ulnar nerve. The comparative immunity from anæsthesia after injury to nerves has been ascribed, by Arloing and Tripier, to the communication of the terminal sensory filaments of adjacent nerves with one another. This explanation does not apply to all cases. In view of the fact that a similar phenomenon is also observed in diseases of the spinal cord, it is probable that a lesion which, when it affects a motor fibre, will interfere entirely with conduction, will not produce the same effect upon a sensory fibre, either because the structure of the latter is more resisting, or because it reacts more readily to stimuli.

Delayed conduction of sensibility has been observed in a very few cases in connection with anæsthesia due to lesions of the peripheral nerves. Erb reported an instance of this kind in a case of injury to the brachial plexus, and Westphal mentions a similar case. Stern has also reported delayed conduction of the sense of temperature in a case of multiple neuritis.

The term *analgesia* is applied to loss of the sense of pain. This is usually coextensive with the other forms of cutaneous anæsthesia, when the condition is due to an affection of the peripheral nerves, though the sense of pain is also retained in many cases. The term *anæs-*

thesia dolorosa is applied to those cases in which the affected part is anæsthetic, but the patient suffers from severe pains in the part. This is the result of interference with conduction in the affected nerve, while at the same time the lesion causes irritation of the central portion of the nerve. The irritation is reflected in consciousness to the terminal distribution of the nerve. This symptom is especially apt to occur in compression of the spinal roots of the nerves, such as is produced at times in the paraplegia of Pott's disease, but much more frequently in cancer of the vertebræ.

Peripheral anæsthesia is also observed at times, in the later stages of severe neuralgias, in the distribution of the painful nerve.

As a general thing, anæsthesia from lesion of the peripheral nerves is complete, *i.e.*, it affects all forms of sensation in an approximately equal degree. It seems probable, however, that this would be found to be not so constant as is commonly believed, if the cases were examined more carefully with reference to this point.

Cutaneous anæsthesia may be unattended with any other symptoms, and may not be discovered until after examination by the physician, or until the patient finds that he has unwittingly injured the part by reason of the lack of sensibility. In the majority of cases, however, it is attended with paræsthesiæ (perversions of sensibility), such as numbness, formication, a feeling of furriness, etc. When the anæsthesia is the result of lesion of a mixed nerve (except in neuralgias) it is usually less marked than the coexisting paralysis of the muscles supplied by the same nerve.

In anæsthesia of the hand the patient is unable to perform delicate movements with the part unless aided by the sense of sight, and even then he is somewhat awkward in his movements.

In anæsthesia of the soles of the feet the so-called Brach-Romberg symptom may be produced. If the patient, while standing, is directed to close the eyes when the feet are brought closely together, he totters from side to side, and may even fall to the ground. Equilibrium is maintained normally by centripetal impressions from the skin, muscles, and the semicircular canals of the ears. When the former are abolished, as in anæsthesia of the soles of the feet, the other two may be unable to maintain complete equilibrium unless aided by the sense of sight.

Anæsthesia is a very frequent symptom of diseases of the spinal cord, and inasmuch as the paths of conduction of the individual fibres for the different modes of sensation here separate more widely than in the peripheral nerves, it is much more often partial than is anæsthesia due to diseases of the nerves.

In certain cases—for example, in incomplete ether or chloroform narcosis—the tactile sensation is preserved, while the sensation to pain is entirely lost. The patient, although conscious of the individual steps of an operation, is insensible to pain. It is even possible that the sense of heat may be intact, while that of cold is abolished. Herzen reports a case of myelitis of the posterior columns of the cord and of the direct cerebellar tracts, with intact anterior columns and gray matter, in which there was complete and permanent tactile anæsthesia of the lower limbs, and abolition of the sense of temperature of cold substances; while the sense of pain was normal, and likewise the sense of heat between the temperatures of 60° to 27° C. (140° to 80.6° F.). Herzen concludes that the sense of heat passes through the gray matter, the sense of cold and tactile sensation through the posterior columns. Goldscheider also comes to the conclusion, from his experiments, that there are special nerves for the sense of cold, heat, and touch.

When only certain forms of sensation are affected the sense of pain is lost much more often than that of touch, and when both are combined the affection of the former is usually much more marked than that of the latter. In much rarer cases the sense of temperature or of pressure is lost, while that of touch or of pain is retained. In the majority of cases, however, there is merely relative intactness of one or more modes of sensation.

It is particularly in diseases of the spinal cord that we meet with delayed conduction of sensibility. This, like the anæsthesia, may affect the different modes of sensation in different degrees. As a general thing, it is noticed chiefly with regard to the sense of pain or of touch, the former being the one which is usually delayed. If the patient is pricked with a pin he first makes the signal indicative of his perception of the touch, and then, at the end of a variable period (from one to four or five seconds, and even a much longer interval has been reported), he indicates the perception of pain. This condition is observed much more frequently in locomotor ataxia than in other diseases of the spinal cord. It is a singular fact that the delay in conduction is often less the more violent the painful impression is, and that it sometimes disappears temporarily during the course of the examination (Stern). In rare cases there is a similar delay in the conduction of the sensation of temperature. It has been found, however, that the transmission of the sense of temperature is slower than that of touch, even in the normal condition. Anæsthesia of muscular sensibility is also a frequent accompaniment of severe spinal diseases, and when it is associated, as it almost always is, with cutaneous anæsthesia, the patient "loses his limbs" in the dark. Schueppel reported a case of general anæsthesia (affecting almost the entire surface of the body), with loss of muscular sensibility and muscle sense, in which the patient, when in the dark, felt as if he floated free in the air.

Hysterical spinal anæsthesia may also be associated with complete abolition of muscular sensibility. Duchenne has also reported the abolition of "muscular consciousness" in hysteria. The anæsthetic limbs could only be moved when under the control of the sense of sight. In the dark, movement of the limbs became impossible.

It is often an easy matter to determine the spinal origin of anæsthesia from its distribution, but in some cases this is an extremely difficult problem. The anæsthesia may be distributed irregularly over the body in patches of various extent. This may occur in multiple lesions of the peripheral nerves (multiple neuritis), or the spinal cord (multiple sclerosis). A decision may generally be reached with the aid of the attendant symptoms, particularly by the fact that in this form of spinal anæsthesia cerebral symptoms are usually present, and indicate multiple cerebral sclerosis.

But anæsthesia of spinal origin usually assumes a paraplegic type, and is associated with paraplegia of motion. It results commonly from transverse myelitis, compression-myelitis, and sclerosis of the posterior columns; it is also frequent in hysterical paraplegia. The existence of anæsthesia with intact reflex action from the anæsthetic part is positive proof of its central origin. Spinal anæsthesia is usually associated with disturbance of the bladder, and is thus distinguished from the anæsthesia due to lesions of the cauda equina, which is also paraplegic in its distribution. Bladder disturbances are often absent in hysterical paraplegia, but this variety is usually recognized by the presence of other evidently hysterical phenomena, the absence of changes of electrical contractility, the occurrence of hysterical contractures, and the previous history of the case.

Spinal anæsthesia may appear in the shape of a girdle around the body, when the posterior roots or posterior gray columns over a slight area are affected by the lesion.

In unilateral lesions of the cord the sensory disturbances present a peculiar distribution. If the lesion is confined exactly to one lateral half of the cord, we shall find motor paralysis of the lower limb on the same side, with abolition of muscular sense and preservation or hyperæsthesia of cutaneous sensibility; the latter usually disappears after a while; in the opposite limb the motor power and muscular sense are intact. Ferrier denies, however, that muscular sense is lost on the paralyzed side and retained on the other side, so that the question must be regarded as *sub judice*. In addition, there is usually a narrow zone of anæsthesia above the hyperæsthetic region (on the side of the lesion), and above this there is sometimes a narrow girdle of hyperæsthesia. If the le-

sion is situated above the cervical enlargement, corresponding disturbances are found in the upper and lower limbs. In the majority of cases, however, all these symptoms are not present. In a case under my observation there was simply paresis of motion in one lower limb, and incomplete anæsthesia in the other.

Anæsthesia of almost the entire body has also been observed in spinal affections. This happens, for example, in a lesion of the upper part of the cervical cord, involving the ascending roots of the trigeminus nerve. I have observed a case of this kind (acute cervical myelitis) in which the diagnosis was confirmed on autopsy. In Schueppel's case, to which I have already referred, there was complete anæsthesia of almost the entire surface of the body. The autopsy showed extensive syringomyelia following myelitis, with degeneration of the posterior columns and almost complete atrophy of the posterior roots.

In transverse lesions of the lower part of the lumbar enlargement there may be anæsthesia of both limbs, with the exception of the parts supplied by the obturator and crural nerves (inner surface of the thighs), because these nerves are given off higher up.

In transverse lesions of the upper part of the lumbar enlargement the parts supplied by the obturator and crural nerves may also be anæsthetic.

In transverse lesions of the lower or upper dorsal cord the anæsthesia may extend over the lower limbs and the trunk as high up as the exit of the nerves given off from the site of disease.

In transverse lesions of the cervical enlargement there may be complete anæsthesia of the entire body below the head, and, as we have seen above, almost the entire body may be anæsthetic.

But, as in the case of anæsthesia from lesions of the peripheral nerves, that of spinal origin is very often far less marked than the motor symptoms. Indeed, there may be complete paraplegia of motion without any appreciable loss of sensation. In certain forms of spinal disease this is the rule—for example, in the compression-myelitis of Pott's disease. One case of this disease, however, has been reported in which sensation was alone affected, while the motor power was unchanged.

Anæsthesia is a frequent symptom of cerebral diseases. It is observed often in the ordinary cerebral hemiplegia due to hæmorrhage or to embolism of the middle cerebral artery. It is usually distributed over the entire paralyzed side of the body, but it is rarely as profound as the motor hemiplegia. As a general thing, all forms of cutaneous sensibility are affected alike. It usually disappears much more rapidly than the paralysis of motion. In the beginning it is frequently—much more commonly than is generally believed—associated with hemianæsthesia of the special senses (*vide* article on Cerebral Hæmorrhage). In rare cases the anæsthesia is much more marked than the disturbance of motion, and persists after the latter has disappeared. Hemianæsthesia of the special senses is an almost constant accompaniment of such cases. It results, probably, from a lesion of the posterior third of the internal capsule.

The various forms of sensation are not always affected in a uniform manner in cerebral diseases. In some cases there is abolition of the sense of pressure and temperature, while that of pain remains. A case of hemiplegia has also been reported in which there was abolition of the sense of temperature, with intact sense of pressure and pain. This has been corroborated by Rosenthal.

The relation of anæsthesia to lesions of the cortical motor centres is still the subject of dispute. There can be no doubt that in some cases of destruction of these centres the cutaneous sensibility is intact. But other cases have been reported in which a certain degree of anæsthesia was present, while in others, still, the muscular sense was lost.

The question of the relation of sensory to motor disturbances in diseases of the cortex is an extremely interesting and important one. Physiological experiments upon lower animals are almost entirely valueless in this respect, and pathological observations which are beyond criticism are extremely rare. The only thing in this connection which seems to be tolerably clear is, that muscular sense may be abolished, without paralysis of motion, in lesions of the parietal lobe. The weight of evidence also seems to me to favor the view that the centre of cutaneous sensibility is situated in the parietal lobe. It is unnecessary for us to say that many writers deny the existence of true motor centres, and claim that the so-called motor centres are really sensory, and that in cortical paralyses cutaneous sensibility and muscular sense are always affected at the same time. Anæsthesia may also appear in any organic disease of the brain (tumor, softening, abscess) which involves the sensory fibres in any part of their course, either directly or by pressure from a distance. In very rare instances hemianæsthesia may result from cerebral syphilis. Only four cases of this kind have been reported, to my knowledge—one by Fournier, three by myself. In these cases all forms of cutaneous sensation were affected, and, in addition, there was hemianæsthesia of the special senses on the same side. The sensory disturbances were associated with hemiplegia of motion in all the cases.

Hemianæsthesia of cerebral origin is not uncommon in hysteria. It is often unrecognized by the patient until an examination is made by the physician. Not alone is the integument of one-half of the body completely anæsthetic, but the sensibility of the mucous membranes and muscles, and often of the special senses on the same side of the body, is also abolished. Hysterical hemianæsthesia may or may not be associated with a corresponding hemiplegia of motion. In rarer cases hysteria is characterized by anæsthesia of the entire body. It is also not uncommon to find in this disease circumscribed patches of cutaneous anæsthesia alternating with patches of hyperæsthesia.

Hemianæsthesia has also been observed in various lesions of the pons Varolii and cerebral peduncles. The distribution is similar to that occurring in lesions of the posterior part of the internal capsule, except that sight and smell remain intact.

Hemianæsthesia, similar to that of hysteria, has also been reported in cases of chronic lead-poisoning, chronic alcoholism, and mercurial poisoning.

Anæsthesia is a not very infrequent symptom of various forms of insanity. It may involve only a small part of the integument, it may be unilateral in its distribution, or it may be present over almost the entire body. It sometimes involves the deeper structures. Rochoux reports a case in which a lunatic kept his arm in the fire until the flesh was burned off down to the bones. The anæsthesia generally affects all forms of sensation, but sometimes appears to be partial.

Circumscribed anæsthesia, especially in the distribution of the trigeminus nerve, is not rare in severe cases of melancholia. In such cases there may also be incomplete anæsthesia of the entire integument.

In acute primary stuporous dementia there may be complete anæsthesia of the entire integument, so that no impression from the outside appears to be able to reach consciousness.

Anæsthesia is also not uncommon in progressive general paresis. It is probably always present in those cases which are combined with posterior spinal sclerosis, and is also noticed in uncomplicated cases.

The anæsthesias of insanity often form a basis for the patient's illusions, and, according to some writers, may furnish a clew for treatment of the mental affection.

Oppenheim and Thomsen have applied the term "mixed (sensory-sensible) anæsthesia" to a peculiar condition which they observed in quite a number of cases of insanity and diseases of the brain. "It forms a typical symptom-complex, consisting of blunting or abolition of cutaneous sensibility in all or several qualities (bilaterally, unilaterally, or in patches), and a coincident blunting of the special senses (concentric narrowing of the field of vision of both eyes), with or without impairment of the color sense and muscular sense." The symptoms were observed in cases of dementia, chronic paranoia, and transitory conditions of terror and confusion. According to Thomsen, the symptoms are not the result of

the psychosis itself, but rather of the etiological factors of the latter. These were found, in the majority of cases, to consist of alcoholism, injury to the head, and epilepsy, either singly or in combination. The anæsthesia was sometimes temporary, sometimes it appeared to remain unchanged for years.

According to these writers "mixed anæsthesia" also occurs in epilepsy, hysteria, hystero-epilepsy, alcoholism, nervous excitability, neurasthenia, chorea, conditions of terror, railway spine and injuries to the head, multiple sclerosis, Westphal's neurosis, and organic diseases of the brain. Almost all of the patients present some psychical anomalies.

Schuetz has also reported a case of paranoia with total anæsthesia of the entire body (with the exception of the right ear, lips, and fingers of the right hand), concentric narrowing of both fields of vision, anæsthesia of the special senses on the left side, and complete loss of muscular sensibility.

Hyperæsthesia, in the strict sense of the term, is an exaggeration of sensibility. This condition is rare. It is sometimes observed under normal conditions, for example, in the blind, who endeavor to replace the sense of sight by cutaneous sensibility, and who finally become able to detect much more delicate impressions upon the skin than those who are possessed of the sense of sight. It is also seen in various occupations in which the cutaneous sensibility is being brought constantly into play. True hyperæsthesia is sometimes seen in hysteria, especially in somnambulistic conditions. It has also been observed in the first stages of acute mania. But in the majority of such cases the special senses are particularly apt to be hyperæsthetic.

True cutaneous hyperæsthesia (hyperpselaphesia of Eulenburg) is also observed occasionally as the result of peripheral changes, and may affect any of the different forms of cutaneous sensibility. The sense of temperature is sometimes exaggerated after the application of a blister, in the painful region of herpes zoster, and in rare cases of locomotor ataxia. Tactile sensibility may also be exaggerated under similar conditions.

The term hyperæsthesia is applied ordinarily to conditions which are more properly called *hyperalgia, i.e.,* the production of pain after impressions which ordinarily give rise to mere sensations of touch, pressure, etc., as, for example, when gentle stroking of the skin in the hyperæsthetic zone of herpes zoster gives rise to severe pain. Such conditions are associated, as a general thing, with true anæsthesia.

Hyperalgia may be the result of affections of the peripheral nerves, the spinal cord, and the brain. It is a frequent symptom in the first stages of various neuralgias, but usually gives way, after a while, to anæsthesia, limited to the distribution of the affected nerve. It is also a very common symptom after injuries of the nerves (gunshot wounds, contusions, etc.), and may then be associated with muscular hyperæsthesia. It is also an almost constant symptom in neuritis, and in such cases is generally associated with anæsthesia. In a case of neuritis of the brachial plexus, affecting mainly the radial nerve, and at present under my observation, there is exquisite hyperæsthesia of the integument and muscles supplied by the affected nerve, although the most careful examination fails to reveal the slightest disturbance of sensation in any other respect. Even holding the newspaper in the hand for a little while soon causes an intolerable peculiar pain in the skin and muscles. In certain of these cases muscular hyperæsthesia is observed independently of cutaneous hyperæsthesia.

The latter is also a constant attendant of causalgia, or the burning pain in the skin, first described by Weir Mitchell, after injuries to nerves, and which is usually attended with glossy skin or other trophic changes in the cutaneous appendages.

Hyperæsthesia is also observed quite often in diseases of the spinal cord. It is a very early symptom in spinal meningitis, and affects the integument and the deeper parts. At the same time, the cutaneous and tendon reflexes in the hyperæsthetic region are usually diminished, as the result of pressure on the roots of the nerves. It is sometimes observed in acute myelitis, but is by no means as frequent as anæsthesia. It generally occurs as hyperalgia.

In locomotor ataxia, likewise, hyperæsthesia is much less frequent than anæsthesia. It is often observed during the time when the patient is suffering from the fulgurating pains, and is then usually confined to circumscribed patches of skin. It generally disappears with the pains. Stern reports two cases in which the hyperæsthesia seemed to affect only the sense of touch. When the patches were gently touched with a pencil, a sensation of scratching with a needle was produced, but no feeling of pain. Hyperæsthesia to the sense of cold alone is also observed in tabes, and may be widely diffused over the body. The patients then complain of pain on being touched with cold objects, which cause no disagreeable sensation in healthy individuals.

Leyden has also called attention to a condition in tabes to which he has applied the term "relative hyperæsthesia." The patients are anæsthetic so far as regards feeble stimuli, but when the stimulus reaches a certain degree of intensity an exaggerated painful sensation is produced.

In unilateral lesions of the cord hyperæsthesia is said to be sometimes present over the entire limb on the same side as the lesion. In addition, a narrow girdle of hyperæsthesia around the trunk is sometimes observed above the narrow zone of anæsthesia.

Unilateral hyperæsthesia also occurs, in rare cases, in diseases of the pons. In some cases of pons lesions, hyperæsthesia, confined to the trigeminus nerve on the side of the lesion, has also been observed.

In cerebral hæmorrhage hemihyperæsthesia is observed rarely on the paralyzed side. It usually occurs some time after the disappearance of the hemianæsthesia, and lasts a variable length of time. It is not uncommon to find exquisite hyperæsthesia around the joints after contracture, secondary to hemiplegia, has occurred.

In tumors of the brain localized hyperæsthesia in some part of the skull (sometimes corresponding very closely to the locality of the tumor) is a quite common symptom. Hyperæsthesia of the trigeminus is observed less frequently under such circumstances.

In ordinary acute meningitis there is very often exquisite hyperæsthesia of the entire body, so that the patient shrinks at the slightest touch. This is also true of tubercular and basilar meningitis, and the hyperæsthesia is often so marked that the patient reacts to a slight stimulus with evident signs of pain, even though he is in a semi-unconscious condition.

Neurasthenia (nervous exhaustion) is often associated with localized hyperæsthesia over the spine (spinal tenderness), and sometimes with diffuse hyperæsthesia over the entire body. Hyperæsthesia limited to certain parts of the limbs is also observed in some of these cases. It usually consists of hyperalgia, but in rarer instances the sensibility to heat or cold is alone exaggerated.

Circumscribed hyperalgia is often found in migraine in the parietal region, or there may be diffuse hyperalgia of the entire side of the head. Berger also describes, in migraine, exaggerated sensibility to touch (hyperpselaphesia) and to temperature over the painful side of the head.

Hyperæsthesia is observed rarely in syphilis as a prodrome of syphilitic hemiplegia, and this may continue for some time after the paralysis has developed. It has also been noted in syphilis of the spinal cord, usually associated with paralysis.

It occurs in various ways in hysteria: there may be exaggeration of the tactile sense, or muscular sense, but more frequently of the special senses. There may even be exaggeration of individual qualities of cutaneous sensibility. For example, the perception of pulsation in different parts of the body, although the pulsation is not increased in violence, depends probably on a true hyperæsthesia of the sense of pressure in the parts.

The cutaneous sensibility may be so excessive that even the contact of a slight current of air is distressing to the

patient. Hysterical hyperæsthesia may affect the entire integument or only one side of the body. It is often confined to a circumscribed region, such as the back, the lateral or anterior surface of the chest and abdomen, the limbs, the vulva, the mammary glands, the region of the ovaries.

The term *paræsthesiæ*, or perversions of sensation, is applied to those conditions in which the sensation following a stimulus differs in kind from that normally produced under similar circumstances. In the large majority of cases these paræsthesiæ are not preceded by external stimuli, but appear to result from abnormal processes in the nerves or central nervous system. These sensations include itching, formication, numbness, and unusual feeling of heat (ardor), etc. When they are accompanied by pain, the term *paralgesiæ* is sometimes employed.

Pruritus (itching) is a peculiar sensation that cannot be defined clearly in words. It is usually symptomatic, but may also appear as an idiopathic affection. It is found in numerous skin diseases, in wounds during the formation of granulations, in jaundice, scarlatina, measles, diabetes, etc. In all such cases the symptom is generally attributed to irritation of the nerve terminations in the cutaneous papillæ, either by morbid exudations or by the presence of noxious elements in the blood. In much rarer cases pruritus is an idiopathic affection of the skin, unattended by an eruption—except such as occurs secondarily to scratching—and usually confined to circumscribed parts, though in some cases, especially in old people, it involves almost the entire integument.

Formication is the term applied to a sensation variously described as numbness, "crawling of ants," "falling asleep," etc. Unlike pruritus, it is not often produced by irritation of the terminal filaments of the nerves, but usually results from partial interference with conduction along the course of the peripheral nerves or the sensory tracts in the central organs. It may also result from the presence of poisonous elements in the blood, as, for example, in poisoning by ergot, opium, or veratrine.

One of the most frequent causes of formication is compression of the nerves. This has been experienced by everyone, in the parts supplied by the ulnar nerve, from a blow on the "funny-bone." It is often found in the more severe forms of nerve lesions attended with motor paralysis. In such cases it is usually accompanied by anæsthesia, but it may also exist independently of the latter.

Formication is also a frequent symptom in various forms of diseases of the spinal cord, especially in acute and chronic myelitis and locomotor ataxia. In myelitis it is generally experienced first in the legs and soles of the feet. Before any demonstrable changes in sensation can be detected by examination, the patient complains of a feeling of numbness in the feet, as if he were walking on velvet or a cushion of air, etc. As the disease advances this symptom generally gives place to anæsthesia. In locomotor ataxia the feeling of formication may be experienced in circumscribed parts of the body, but begins commonly in the soles of the feet. Formication in the distribution of both ulnar nerves often precedes for a long time the development of the ataxic symptoms in the upper limbs.

This symptom is also very frequent in hypochondriasis, and may appear in any part of the body. It often furnishes the basis upon which the patient erects a whole complex of symptoms. For example, if such an individual experiences formication in the back, he is apt to infer that he is suffering from some disease of the spinal cord, and "expectant attention" soon enables him to furnish a multitude of other symptoms.

In hysteria, neurasthenia, and other neuroses, formication also plays its part as a minor symptom.

The terms *ardor* and *algor* are applied to feelings of unusual heat and cold of the skin, when they arise independently of an adequate external cause. These sensations are usually, though not always, associated with a corresponding congestion or anæmia of the parts, as in the paroxysms of intermittent fever, the onset of acute infectious and febrile diseases, and in various disturbances of the vaso-motor system. They are sometimes observed independently in hysteria and neurasthenia, and are very frequent in nervous women at the menopause. A very distressing and constant sensation of heat over the entire body is also a common symptom in paralysis agitans.

Charcot first applied the term *dysæsthesia* to a peculiar condition, which he described as follows: "It is a sort of hyperæsthesia in which the slightest irritation, such as a slight pinch, or the application of a cold body, gives rise to a distressing sensation, which is always the same whatever may be the nature of the stimulus, and in which, according to the statements of the patients, a feeling of vibration predominates. These vibrations appear to ascend and descend the limb at the same time. In the majority of cases the sensations persist for some minutes, sometimes for a quarter of an hour or more, after the cessation of the cause which gave rise to them. In such cases the patient always experiences great difficulty in accurately localizing the place where the irritation had been produced. Finally, it is not rare that the stimulation of one limb, after having given rise to the phenomena indicated, is followed, at the end of some time, by an analogous sensation, which appears to be situated in a part of the opposite limb corresponding to the region primarily stimulated."

The phenomenon in question has been observed by Charcot in the compression-myelitis of Pott's disease, and in acute and chronic dorsal myelitis.

Allochiria is a peculiar perversion of sensibility, which was first described, in 1881, by Obersteiner. The term is applied to the following condition: "When we test the sensibility of a patient on the leg, for example, and find that the two points of the æsthesiometer are recognized as such at a moderate distance apart, or when a prick or pressure is fairly localized, and yet, as frequently occurs, the irritation is referred to the other side, we have the condition before us. The power of localization is retained as to details, while doubt or error exists as to the side touched, the irritation being commonly referred to the corresponding part of the other limb."

This symptom seems to have been observed in a very few cases of locomotor ataxia, compression-myelitis of Pott's disease, and hysteria.

Oppenheim has recently described a peculiar perversion of sensation, the significance of which is entirely unknown, in unilateral lesions of the brain. If the two sides of the body are subjected simultaneously to stimuli of equal intensity, the sensation is felt only on the healthy side, but is perceived on the paralyzed side when the latter is irritated alone. The stimuli are perceived on both sides if that on the paralyzed side is applied with greater intensity. This symptom was observed in only four cases of unilateral disease of the brain, although a large number of such cases were examined. It never occurs in healthy individuals.

Polyæsthesia is a rare disturbance of sensation, first described by Brown-Séquard, in which the point of a pin, when applied to the skin, is felt as two or more points.

Naunyn applies the term *after-sensation* to a peculiar disturbance which he noticed in locomotor ataxia. The pain produced by the prick of a pin rapidly disappears at first, but soon returns at the point of irritation, and then may increase in severity and persist for hours. I have also observed this symptom in cases of chronic myelitis, but the pain was not as persistent as described by Naunyn.

VISCERAL SENSATIONS.—It is very probable that the action of all the viscera, particularly those of the thorax and abdomen, is attended by a specific effect on the brain. In the normal state this does not rise to the level of consciousness, but merely affects the mood of the individual. In disordered action of the viscera, however, or of the nerves which supply them, this visceral stimulus often is converted into a conscious sensation, usually of a vague, distressing character, which may be referred either to the organ which is the seat of disordered action, or to remote parts of the body. Everyone is probably aware of the mental depression which is as-

sociated so often with constipation, and which disappears at once after a free evacuation from the bowels. The disordered action of any viscus may exercise an injurious effect in the same way.

We will now enter briefly into the consideration of the more important disturbances of visceral sensation.

Hunger is a peculiar sensation that need not be described in words; it is commonly referred to the stomach, although it is really an expression of the want of food by the general system. In certain cases there is a morbid increase of hunger, known as boulimia, which is observed chiefly in diabetes, hysteria, epilepsy, mania, general paralysis of the insane, and sometimes in cerebral syphilis. Romberg and Liveing state that this symptom sometimes occurs as a forerunner of the gouty paroxysm. In one case Eulenburg observed it, in connection with hemicrania, in a non-hysterical girl of twenty-one years of age. Willis and Liveing also mention a couple of cases in which boulimia occurred as a prodromal symptom of migraine. In rare instances it appears to be an independent neurosis. In a case under my observation it was transmitted from father to son.

In these cases the patient, even within a short time after a hearty meal, or perhaps on awaking from a sound sleep, is seized with an irresistible and sudden feeling of hunger, and devours large quantities of food. At other times the ingestion of a small amount of food serves to relieve the distressing symptoms. In severe attacks the feeling of hunger may be associated with general tremor of the body, a profuse outbreak of perspiration, and a feeling of faintness which may become almost insupportable. At the same time there may be an uneasy, gnawing sensation, with a feeling of sinking in the gastric region. Boulimia has been attributed to an anæsthesia of the gastric branches of the pneumogastric nerve, but this is by no means clearly proven. It is quite certain that the condition is of central origin in many cases. Some writers believe that it is due to an affection of the sympathetic. It belongs, in all probability, among the paræsthesiæ.

The term polyphagia indicates a condition in which satiety is not produced until an enormous amount of food has been ingested. In a number of cases of this kind, lesions of the pneumogastric have been found, and the affection is probably the result of anæsthesia of this nerve. This symptom is observed in hysteria, epilepsy, various forms of insanity, diabetes, and also in diseases of the medulla oblongata.

Thirst is an indication of the want of fluid felt by the general system, but may also arise from dryness of the mucous membrane of the palate and pharynx. Polydipsia is a morbid exaggeration of thirst. It is observed in diabetes mellitus and insipidus, and occasionally in hysteria. Cohnheim has expressed a doubt as to the occurrence of primary polydipsia, but this doubt is dispelled by the experience of Nothnagel. The latter writer reported a case in which polydipsia developed acutely half an hour after a fall on the back of the head which was attended with unconsciousness. This was followed, at the end of two to three hours, by a permanent increase in the excretion of urine. The symptom was probably the result of an injury to the medulla oblongata.

Fright is almost always associated with disturbed action of the heart, and in many cases it seems to be the result of hyperæsthesia of the sensory fibres distributed to that organ. This condition is known as præcordial fright. In uncomplicated cases the patients suffer from a feeling of impending dissolution, and, at the same time, of unspeakable anguish, attended with a distressing sense of oppression in the region of the heart. As a general thing the cardiac action is feeble, often irregular; during the attack the pulse is correspondingly feeble, the skin pale and covered with cold perspiration. In rarer cases the action of the heart is strong and forcible, the pulse full and bounding, and the face congested. The symptoms on the part of the pneumogastric are sometimes attended by phenomena which must be referred to the glosso-pharyngeal nerve, viz., a feeling of scratching in the throat, and a sense of dryness and constriction in this region. In some cases there is an intense feeling of "goneness," which is referred to the epigastric region. This may be attended or followed by profuse watery diarrhœa, or the discharge of so-called spastic urine. In severe attacks there may be confusion of ideas, and this may even pass into complete unconsciousness of the surroundings.

Præcordial fright sometimes develops in healthy individuals during dreams, especially after partaking of a heavy, indigestible meal. In the midst of a troubled, uneasy sleep there is a sudden awakening, with an agonizing sense of vague fear, a feeling of great oppression about the heart, and severe palpitation, or perhaps a few labored heart-beats. The symptoms subside in a few moments. This condition is probably a reflex symptom of irritation of the pneumogastric in the stomach.

But fright is not always of a præcordial character. It is sometimes of an indefinable general character, without any special localization. This is seen not infrequently in cases of hypochondriasis, cerebral syphilis, and at the onset of various acute infectious diseases, particularly in miliary tuberculosis. Samt states that he himself suffers from attacks of fright which are localized in the frontal region. Other localizations have also been reported.

Præcordial fright is a frequent symptom of nervous diseases. It is observed in the night terrors of childhood, where it is often the result of some reflex irritation, but is sometimes indicative of a close relationship with epilepsy. It is also seen in true epilepsy and hysteria. It may be a prodromal symptom of migraine, and, in rare cases, occurs prior to an attack of cerebral hæmorrhage. It has also been seen in acute and chronic meningitis, in rupture of an abscess, or in hæmorrhage into the ventricles of the brain. In a number of instances I have observed it in cerebral syphilis, sometimes in the absence of any other evidences of local brain disease. In angina pectoris it constitutes almost the entire malady, and may or may not be associated with organic disease of the heart or great vessels. In like manner, it is a not infrequent symptom of neuralgias of the abdominal organs. In a case of enteralgia under my observation the condition was very pronounced, and, at the same time, there was extreme dyspnœa.

Præcordial fright also appears in various forms of insanity, but plays its most important part in melancholia. In the latter affection it is often the immediate cause of deeds of violence (melancholic frenzy). Literally beside himself with terror, the patient employs violence against himself or others, in the effort to free himself from the feeling of oppression.

This condition is usually regarded as a paræsthesia or hyperæsthesia of the various sensory nerves of the heart, more rarely of the abdominal sympathetic ganglia. But this theory is by no means proven. In the first place, fright is not always præcordial in character. It is sometimes so vague as to be incapable of localization. Moreover, it plays a part sometimes in diseases which are undoubtedly cerebral in character, such as epilepsy and migraine. It seems to me to be more plausible, therefore, to regard the condition in such cases as the result of a cerebral disturbance, probably in the cortex, which is conveyed to the centres of innervation of the heart, and sometimes to other nerves (glosso-pharyngeus, etc.). In other cases it seems to result from increased irritability of the nervous supply of the heart or abdominal viscera, though even then it cannot be denied that there may also be a primary cerebral disturbance without which the peripheral hyperæsthesia would prove inefficient.

Excessive voluptuous sensations may be the result of peripheral or central causes, the latter being much more frequent than the former. This condition is observed in various diseases of the female genitals (vagina, uterus, ovaries), rarely in affections of the male genitals, in diseases of the urinary apparatus and intestines (helminthiasis). Romberg has observed it in neuralgia of the spermatic plexus. Sexual hyperæsthesia is also observed in diseases of the spinal cord, such as locomotor ataxia and

multiple sclerosis, probably as the result of irritation of the lumbar genital centre. This condition must be distinguished from priapism, which is generally unattended with increase of the sexual sensations. Among cerebral diseases it is observed in epilepsy (sometimes as a prodromal symptom, sometimes during epileptoid states), hysteria, hypochondriasis, the initial stages of melancholia, and acute mania. Sexual hyperæsthesia is also observed occasionally during convalescence from acute diseases, and very often during phthisis. It is a frequent symptom of hydrophobia. We have also noticed it very often during the menopause, sometimes even after the sexual desire had been abolished for a long time.

Sexual anæsthesia is observed more often in men than in women as an acquired condition. In women it is found often as a symptom of hysteria, perhaps associated with anæsthesia of the mucous membrane of the vulva and vagina. A similar anæsthesia of the glans penis is not infrequent in males, as the result of excessive onanism or prolonged sexual excesses of any kind, and is often associated with anæsthesia of the urethra and prostatic sinus. These are the cases in which disgusting sexual abuses are so often found, because the patient must resort to some other than the natural mode of stimulation of the genital centres in order to consummate the sexual act, *i.e.*, to secure the orgasm.

Sexual anæsthesia is also seen in locomotor ataxia, multiple sclerosis, and other cord diseases, and in numerous conditions of general exhaustion, particularly when associated with mental depression. It not infrequently forms the basis of insane delusions, especially in the female. *Leopold Putzel.*

SEPTICÆMIA AND PYÆMIA. In his admirable description of the repair of wounds, Billroth devotes a section to the "general accidental diseases which may accompany wounds and other local inflammations." He states that in the great majority of cases, in wounds of any size, fever occurs sooner or later, and of these fevers he discusses at length three forms, viz., (*a*) traumatic and inflammatory fever; (*b*) septic fever and septicæmia; (*c*) suppurative fever and pyæmia. The clinical history of these fevers may be summarized from his treatise as follows:

1. Traumatic and Inflammatory Fever.—Possibly even on the first day of the operation the patient may have been restless toward evening; he may have felt hot and thirsty, with no appetite, some headache, wakeful at night, and dull the next morning. These subjective symptoms increase until the evening of the next day. If we feel the pulse we find it more frequent than normal, the radial artery is tenser and fuller than before, the skin is hot and dry; the bodily temperature is elevated; the tongue is coated and readily becomes dry. The patient has fever. In many cases, especially where the injury has affected tissues previously healthy, the fever does not begin till the second day, increases rapidly, and, with evening remissions, remains for some days at a certain height, and then ceases gradually, rarely within twenty-four hours. Traumatic fever usually lasts a week. As long as the constitutional symptoms, especially those due to the fever, do not extend beyond this limit, and especially if the disease does not prove fatal, the terms traumatic, suppurative, or secondary fever are satisfactory. But, if other symptoms occur, and death results, these severer infections have two other names, "septicæmia" and "pyæmia."

2. Septic Fever—Septicæmia.—This kind of fever differs from the former in the greater disturbance of the wound, and the severer constitutional symptoms. The local infection is very extensive, with phlegmonous inflammation and putrefaction. The patients are apathetic and sleepy, if not entirely comatose; there may be great excitement, and occasionally maniacal delirium; the tongue is dry, often hard, and hence the speech is peculiar; the thirst is great, but patients may be too stupid to ask for water; there may be diarrhœa, but rarely vomiting; sweating may be profuse at first, but later the skin is dry and flabby; the urine is scanty, very concentrated, and occasionally albuminous; the urine and fæces are later passed in bed; bed-sores over the sacrum early occur; the *fever*, as shown by the bodily temperature, at first rises high; in acute pure septicæmia intercurrent chills *never* occur in the course of the disease, and initial chills are very rare. Later in the disease the temperature falls to the normal, or even below it; usually the patient dies in perfect collapse, with a thread-like, very frequent pulse; often the agony lasts over twenty-four hours. This is the usual course of acute pure septicæmia from recent injuries. The post-mortem conditions in fatal septicæmia vary; frequently the internal organs present no morbid appearances; if, however, there was continued profuse diarrhœa, the solitary and conglobate intestinal glands will be found swollen; the spleen is often enlarged and softened, rarely it is of normal size and firmness; the liver is usually full of blood, relaxed, and very friable, but without further change. In the heart the blood is lumpy, half-clotted, tarry, and rarely firmly coagulated. In most cases the lungs are normal, but sometimes there is diffuse single or double pleurisy of moderate extent, and also traces of pericarditis. As nothing special has been found on chemical analysis of the blood from the bodies, what we find post mortem adds little that is characteristic to the picture of the disease.

3. Suppurative Fever—Pyæmia.—The characteristic course of a case of pyæmia is as follows: Supposing the patient to be suffering from compound fracture of the leg, just above the ankle, he may feel very well and have but little fever till about the third or fourth day, when the wound becomes more inflamed, secretes relatively little pus; the surrounding skin becomes œdematous and red; the patient grows very feverish, especially toward evening; the swelling increases and slowly spreads, the whole leg becomes swollen and red, the ankle-joint very painful; on pressure over the leg a thin, badly smelling pus flows slowly from the wound; the swelling remains limited to the leg; there is no trouble of the mind, no sign of intense, acute septicæmia; the patient is exceedingly sensitive to every dressing, he is restless and discouraged; there is febris continua remittens, with high evening temperature, and frequent, full, tense pulse; the appetite is lost, and the tongue heavily coated. This would be about the twelfth day of the injury. Quantities of pus flow from different parts of the wound; somewhat above it fluctuation is distinct; this collection of pus may be evacuated through the wound by careful pressure, but the escape is greatly impeded, and an incision must be made at the above point. This being done, a moderate quantity of pus is evacuated; a few hours later the patient has a severe chill, then dry, burning heat, and, lastly, profuse sweating. The appearance of the wound improves somewhat, but this does not last long; we soon notice a new abscess near the wound, but rather behind it in the calf; there is another chill; more counter-openings are required at different spots to give exit to the pus, which forms in quantities. The left leg is the injured one; some morning the patient complains of great pain in the right knee-joint, which is somewhat swollen, and is painful on every motion. The nights are sleepless, the patient eats very little, drinks a great deal, and becomes much debilitated; he emaciates, especially in the face; the color of the skin changes to yellowish, the chills recur; the patient then begins to complain of pressure on the chest; he coughs some, but raises little sputum; on examining the chest you find a moderate pleuritic exudation on one or both sides, from which, however, the patient does not suffer much, but he complains more of the right knee, which is now much swollen, and contains a great deal of fluid; as the patient sweats a great deal, the urine becomes very concentrated, and is occasionally albuminous. Finally, bed-sores develop, but the patient does not complain much of this; he lies quietly, half-insensible, muttering to himself. This would be about the twentieth day after the injury. The wound looks dry, the patient looks miserable; the face, and especially the neck, is emaciated; the skin is very jaundiced, the eyes are dull, the trembling tongue is perfectly dry, the skin

cool, the temperature low, and only elevated at evening, the pulse small and frequent, the respirations slow, the breath of a peculiar cadaveric odor; the patient becomes entirely unconscious, and may, perhaps, remain so for twenty-four hours before death. On autopsy you find nothing pathological in the skull; heart and pericardium normal; in the right auricle and ventricle a firmly coagulated, white, fibrinous clot; both pleural cavities are filled with a cloudy, serous fluid; the surfaces of the lungs are covered with a net-like layer of jaundiced fibrine; on tearing this off, under it, in the substance of the lung, but particularly on its surface, you find quite firm nodules, as large as a bean or chestnut. These are found chiefly in the lower lobes; sections through them show that they are mostly abscesses. The parenchyma of the lungs, somewhat condensed, forms the capsule of a cavity which is filled with pus and disintegrated lung-tissue. Others of these nodules are blood-red, and, on section, the cut surface is somewhat granular, and in their midst there are occasional spots of pus of various size, making it evident that they change to abscesses. They are red infarctions terminating in abscesses. Some of these abscesses lie so near the surface that they implicate the pleura, and the pleuritis is secondary. The liver is quite vascular and friable, but is otherwise apparently normal. The spleen is somewhat enlarged, and, on section, shows a few firm, wedge-shaped nodules, with their points turned inward, and their broad outer ends along the surface; they resemble the red infarctions of the lungs, and within they also have partly broken down into pus. The intestines and urinary and genital organs show nothing abnormal. An incision into the right knee, which was painful during life, gives exit to a quantity of flocculent pus; the synovial membrane is swollen, and in part hæmorrhagic, injected; the lustre of the articular cartilage is dulled. Examination of the wound shows little more than we found on the living patient, that is, extensive suppuration of the deep and subcutaneous cellular tissue, as well as pus in the ankle-joint; the walls of all these collections of pus consist mostly of broken-down tissue; true granulation has only occurred at a few points. In the veins of the legs there are old plugs of fibrin here and there, also yellow puriform detritus, and in some places pure pus.

In the preceding sketch every surgeon who practised prior to the last decade will recognize a faithful portraiture of the general accidental diseases which formerly so uniformly accompanied wounds and other local inflammations. Any considerable operation - wound not followed by inflammation and fever, was an anomaly that excited universal surprise. A compound fracture of the leg, just above the ankle, caused by the fall of a heavy body, which was not followed by the train of symptoms above detailed, was the rare exception. At all periods of human history the healing of wounds must, from time to time, have been complicated by all of the conditions which we now recognize as septicæmia and pyæmia. In the works of the earliest medical authors, and even of the early historical writers, we discover more or less accurate accounts of the appearance of these affections among the fatal complications of wounds after great battles. But the true nature of these complications was not suspected, and hence we find a great variety of crude explanations and opinions. It is not surprising that the etiology of these wound- and suppurating fevers has excited the interest of surgeons at all periods of this history. Indeed, there is no branch of surgical literature which exhibits a larger range of study and a more thorough analysis of clinical, pathological, and experimental facts than that comprised in the terms septicæmia and pyæmia. The peculiar and mysterious train of symptoms which so often developed when the healing process pursued an unfavorable course, excited the curiosity of even the most ordinary observer, and profoundly interested the student of pathology. And the interest of all surgeons in these affections was heightened by the great fatality which attended the severer forms of fever. No complications of a wound were so serious and alarming as septicæmia and pyæmia. The apprehension of the surgeon, lest these affections be developed, was so great that he often felt compelled to decline operations unless he could choose the locality where they were to be performed, or the season of the year in which to operate. The fear of blood-poisoning following wounds has long delayed the advance of operative surgery. But, happily, the period of doubt and fear has passed away, and the art of surgery has been forever relieved of the greatest obstacle to its complete success. The terms septicæmia and pyæmia belong to the past history of surgery, and their true significance will never again be fully appreciated except by surgeons who neglect preventive measures.

The history of septicæmia and pyæmia must, therefore, comprise one of the most interesting chapters in the science and art of surgery. The practical value of this history to the modern student of surgery is not limited to the mere knowledge of the methods by which experimental physiology has solved an intricate problem of pathology, but it has a far deeper significance. That knowledge is essential to the successful practice of the preventive methods in whatever form they may be undertaken. No surgeon can properly appreciate the immense revolution which has taken place in the practice of surgery within the last decade, and apply his knowledge successfully, who does not first understand, at least in some measure, the nature and details of the investigations which led to that revolution.

This article will be devoted, therefore, to the more salient facts in the history of the investigations into the causes of septicæmia and pyæmia, with a view to illustrate their nature, and the reforms in practice which have grown out of the discovery of the conditions on which these affections depend. To the elaborate work of M. Jeannel ("L'Infection Purulente ou Pyohémie," Paris, 1880) we are chiefly indebted for the historical summary of the investigations into the nature and causes of pyæmia.

Historical Summary.—Many early writers described abscesses in parts distant from the seat of the wound. In 1559, Nicolas Massa reported a case of abscess of the lung consecutive to a wound of the head; in 1561, Ambroise Paré described cases of wounds of the head with secondary abscesses; in 1665, Marchetti attributed abscess of the liver, after wounds of the head, to the descent of the pus through the lungs and pleura; but Boerhaave (1720) first formulated the doctrine that, by the admixture of pus with the blood, this liquid is so changed as to lead to the collections of pus in the organs.

Le Dran (1731) and Heister (1739) adopted the views of Boerhaave. In 1761, Morgagni related several cases in which autopsies revealed pus in the veins, and abscesses in the viscera, after wounds of the head. He attributed their occurrence, says an author, to particles of pus which, having become mixed with the blood and disseminated, are arrested in some of the narrow passages, and, by obstructing and irritating these, offer an obstacle to the circulation of the humors, and become the cause of the production of a much larger quantity of pus than that which was primarily introduced. From this time to the middle of the eighteenth century there were many publications in which cases were reported of abscesses secondary to wounds, with speculations as to the origin of the pus in the abscesses.

Bertrandi, in 1757, presented to the Academy of Surgery, Paris, a memoir on abscesses of the liver following wounds of the head. He regarded abscess of the liver as especially liable to occur when the patient vomited, or had convulsions or epistaxis, which caused a derangement of the circulation of the blood of the head. The result of this derangement was encephalic congestion, and an active descent of the blood in the vena cava superior; the hepatic branches being in a large organ and without action, and also connected by many openings with the ascending cava, become congested, stasis follows, which results in gangrene or suppuration, more frequently the latter.

The opinion that multiple abscesses are due to sympathy was vaguely expressed by surgeons, and among

others by Pigraï, in 1612. Goursaud, in 1759, distinctly enunciated the doctrine that these abscesses were due to paralysis of the nerves of vessels, producing a stasis which resulted in inflammation. Desault adopted the theory (1794), and Larrey, in 1812, reproduced it with additional explanations. Under the term *fièvre jaune*, which he afterward abandoned, he gave very exact clinical descriptions of acute and chronic purulent infection. He regarded it as contagious. In 1817, and again, in 1829, he reported cases and attributed them to sympathetic irritation of the liver and lungs. Sir Charles Bell also adopted the opinion of Desault (1817), but admitted the possibility of latent visceral lesions. Travers, in 1818, in his statement concerning phlebitis, explains the symptoms by a lesion of the nervous system. Begin (1821), Sabatier (1822), and Boissat (1822), accord part of the action, directly or indirectly, to the nervous system. Copland (1844) and Brodie (1858) sustain the influence of the nervous system, the former attributing the action to the ganglionic system, and the latter to a lesion of the cerebro-spinal system.

In 1821, Richeraud advanced a new doctrine, in opposition to the then prevailing doctrine of Desault. He attributed abscess of the liver, following wounds of the head, to the commotion of this organ at the time of the injury. He attached great importance to the large size of the liver, its situation, and its parenchymatous tissue. He ignored the frequency of multiple abscesses of other viscera following wounds, and considered only wounds of the head and abscess of the liver.

Certain writers attributed multiple abscesses to the suppuration of pre-existing tubercles due to the traumatic fever. Though the existence of tubercles had been previously mentioned by authors, it was not until 1817 that the complete theory was broached by Sir Charles Bell. He remarks : "If there be any tendency to disease in this organ, however latent before the injury, it will be developed, and, increasing the constitutional disturbance, endanger the patient's life. It also appears that as wounds, by their sudden and more violent inflammation, produce a corresponding acute attack on the lungs, so do they often, by more gradual influence, bring on a phthisis. . . How often are we inclined to say that the patient who dies after a great operation has fallen a victim to abscess of the lungs, without duly considering how much the stimulus of the knife had to do in exciting this mischief?"

Suppression of suppuration was long considered one cause of the occurrence of multiple abscesses. This was the doctrine of metastasis, pure and simple, viz., the process of suppuration, having been suppressed in the wound, is transferred to the viscera. In 1749, Quesnay entertained the opinion that the pus formed in the vessels, and that the suppression had no effect in producing abscesses of the viscera ; the latter were not caused by the former, but *vice versa*. Boyer (1814) denied this interpretation of the phenomena. "The accidents," he remarked, "which are attributed to the suppression of suppuration appear rather to be the cause, especially in those cases in which the accidents do not precede suppression."

In 1774, John Hunter read his paper on the "Inflammation of the Internal Coats of Veins," which greatly influenced the opinions of surgical pathologists. He demonstrated the entrance of pus from the inflamed vein into the circulation, and while he attributed the fatal termination of phlebitis to the abscesses in the viscera, he did not actually announce the dependence of the abscess upon the preceding inflammation of the veins. Hodgson, in 1816, and later his translator, Breschet (1819), were the first authors who suggested the connection between phlebitis and abscesses of the viscera. The subject was further illustrated by the publication by Ribes, in 1816, of a paper containing researches on the causes of death of puerperal women, in whom he demonstrated the presence of pus in the veins. In 1820, Gendrin instituted an experiment to prove the transformation of blood into pus, a view held by Quesnay and Horne. He mixed one part of pus with eight parts of blood, and proved, with the aid of the microscope, the disappearance of the blood-globules in twenty-four hours. In 1821, James expressed a doubt as to the possibility of the penetration of pus into the vessels, but in the same year Erdmann, studying positive cases of purulent infection with abscess of the viscera, found pus in the inflamed veins, and declared that this was the cause of abscess and of death.

In 1822, Gaspard first attempted to determine the question in dispute by the experimental method, and injected pus into the veins of animals. The pus was first changed by exposure to the air. He had not in view purulent infection, but septicæmia. In 1823, Velpeau published his inaugural thesis, in which he employed the term *infection purulente* to designate the state of the blood altered by pus. Notwithstanding preceding works, the truth of the dogma of the mixture of pus and of blood was not generally received.

In 1826, Velpeau reiterated his views, in an article on "Alterations of the Blood in Diseases." He contended that the vitiation of the blood by pus was the only cause of the lesions, and rejected all primitive inflammation of the solids in the genesis of visceral abscesses. He saw in the purulent secretion of the wound the only source whence the pus was obtained to infect the blood and the general system. In 1828, Piorry advanced the opinion that the blood could be inflamed, and even suppurate, and gave to the disease which resulted from this suppuration the name of *pyohémie*. The researches of Dance (1828–29) had a very important influence on current opinions. In a series of twenty cases, followed by autopsies, he demonstrated the penetration of pus into the circulation, consecutive to phlebitis. He consequently attributed to inflammation of the veins the origin of the complications occurring to those operated upon, characterized by the presence of multiple abscesses of the viscera.

In 1834, Gunther, of Hanover, published a series of experiments of injection of filtered pus into jugular veins, for the purpose, especially, of studying the secondary accidents of phlebitis. He was successful, in twenty-two out of twenty-three operations upon the horse, in creating in the lungs inflammatory and purulent centres analogous to those of *pyohémie*. The general symptoms simulated those of purulent infection, with the difference necessarily appertaining to the constitution of these animals.

The theory, embodied in the title *embolic septicæmia*, consisted of two elements, viz., septic poisoning as the cause of the general symptoms, and vascular obstruction as the source of the abscess. This phase of the subject was largely discussed, especially by D'Arcet, Virchow, Bonnet, Hueter, and Verneuil, but the discussion did not greatly advance the general subject toward a rational conclusion. Virchow, and other writers who coincided with him, grouped these embolic affections under the term *metastatical dyscrasiæ*. Three forms were given :[1] 1, Metastasis associated with the phenomena of embolism, tending to the development of multiple centres of inflammation and their suppuration ; 2, metastasis in which there is something over and above embolism, and quite independent of its occurrence, and which may get well if secondary abscesses do not form in important viscera—septicæmia, ichorrhemia (S. Ringer) ; 3, metastasis combining the phenomena of the two former.

The doctrine of the spontaneous origin of pus in the blood was first advanced by Tessier, in 1838 (*diathèse purulente*). The belief that blood might be transformed into pus is very ancient, and the theory had not previously been applied to pyæmia. Tessier adopted the term *purulent diathesis*, by which he understood a modification of the organism, characterized by a tendency to the production of pus in the solids and coagulable liquids of the economy. This diathesis is manifested under three forms : 1, Purulent fever ; 2, purulent phlegmasia ; 3, the purulent state. The symptoms of rapid suppuration in certain parts of the body are more particularly connected with purulent fever. The formation of pus takes place equally in the liquids and in the solids, unless there is the relation of cause and effect between the two phenomena. In the course of the disease blood may be transformed into pus, and the transformation may be

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general or partial; it may, alone or simultaneously, take place in the blood-vessels or lymphatics; often suppuration occurs only in the tissues and in the parenchyma of organs. From this source arise the flakes of pus found in the current of the circulation, the suppurative coagula of the heart and great vessels, the frequent phlebites, the purulent arthrites, and, finally, the suppurating foci scattered throughout the body, which have been described as metastatic abscesses. The nature of the modification of the organism which gives rise to the purulent diathesis was unknown. Moreover, traumatism is not an indispensable condition; the diathesis and purulent fever can be produced spontaneously under the influence of obstruction; they may exist even before traumatism, which may only prove to be the exciting cause.

At this period, notwithstanding Tessier's opposition, the prevailing opinion was that pyæmia is due to the mingling of pus in the blood. But the experimental method was again to furnish a new series of proofs, establishing a definite conclusion as to the effect of the artificial mixture of pus and blood. In 1842, D'Arcet reported that he had eleven or twelve times injected unaltered pus into the veins of animals; in only two cases were purulent collections, like those of pyæmia, obtained. In all of the other trials there were produced only visceral ecchymoses; the symptoms were those of purulent infection. Donné, in 1844, acknowledged that it was impossible to recognize pus-globules in blood, owing to their identity in form and volume to leucocytes. In 1846, Castelnau and Ducrest, believing that former experiments had not been conducted with sufficient exactness, undertook the injection of pus under conditions most favorable for obtaining visceral abscesses. They made seven experiments. The injection was always made upon dogs, and in the saphena vein, at the external part of the leg. The pus employed was more or less recent, and was always filtered. Five animals died, and two recovered. In one instance there was pulmonary ecchymosis, and in four cases multiple abscesses were fully formed. These abscesses were more frequent and more numerous in muscles and cellular tissue; twice they were found in the kidneys and spleen and in the articulations. The symptoms, in general, strikingly resembled those observed in wounds complicated with pyæmia, due regard being given to the particular nature of the animals operated upon. The conclusions drawn from these experiments were confirmative of the dogma of the mixture of pus and blood as the origin of purulent infection.

Following in the same path, Sédillot, in 1849 (*Brit. and Foreign Med.-Chir. Rev.*, October, 1849), undertook a series of experiments with a view of answering the following questions: "Is pyæmia the result of a diathesis, or is it caused by the introduction of pus into the blood? What is the mechanism of such introduction? Does the pus act as pus, or by means of the products it gives rise to? If it acts as pus, to which of its elements are we to attribute the poisonous properties it seems endowed with? Is it the globules, the granules, or the serosity, separated or combined, altered or unaltered in properties, that give rise to the pyæmic changes and to death? Is the cure possible; and what are the true indications of treatment?" Forty-five experiments were performed on dogs. It appears that after a single injection of a moderate quantity (four grammes) of healthy pus into the veins, the animal recovered, having sustained little inconvenience. Recovery usually took place after the injection of larger quantities (fifteen to twenty grammes), even when this was of a thickened consistency, containing many globules, the symptoms in these cases being much more severe. When the animals did die from the effects of a single injection, the metastatic abscesses were found to be only in the early stages of formation. Even after the injection of fetid pus a recovery took place, the fatal effects of this fluid evidently depending upon other causes than its fetidity. Yet in other cases a smaller quantity of fetid than of healthy pus proved fatal, and a small quantity of gangrenous pus did so speedily. It appeared also from these experiments that "as in man the course of the symptoms observed depends not upon the passage of a certain quantity of pus into the blood at one time, but upon the persistence of the source of pus, so, if we wish to imitate the effects in animals, we must produce analogous morbid conditions by a repetition of the injection of pus at short intervals."

The theory of a purulent diathesis had been proposed in opposition to that of phlebitis and purulent infections by pus supposed to be pure. The theory of a disturbance or rupture of the equilibrium of the vital forces was developed by Chauffard, in opposition to septicæmia and purulent infection by septic pus. The doctrine of Chauffard coincided with that of Tessier in this, that it rejected all mechanical causes of disease, denied to the wound and to its secretions all direct etiological influence, and sought in the individual himself the cause of pyæmia. Without denying spontaneous pyæmia, it nevertheless made the presence of a focus of suppuration, or rather of traumatism, the ordinary condition of development of the disease, and did not admit in any manner the influence of an anterior diathesis. Many authors had previously imperfectly sketched this doctrine, but Chauffard more accurately defined it in the discussion on pyæmia before the Académie de Médecine in 1871. He stated that traumatic fever indicates the expenditure of all of the vital forces of the organism in their participation in the reparation of the wound; it is neither a necessary nor a salutary fever; the organism can with advantage escape it; it is a pathological result of the perturbation, reparative, caused by traumatism; of the effort of the entire being to re-establish its integrity and organize the curative process of suppuration. The proof of the participation of the organism in the process of suppuration is the presence in the blood of leucocytes. The blood of those wounded is, therefore, in a temporary pathological state, or a state of abnormal activity which creates an unstable equilibrium that the least shock disturbs. This equilibrium is destroyed, and the abnormal pus-creating activity is deviated, by one cause or another, from its normal evolution; in the same manner as, under similar circumstances, the cancerous activity begets all cancer, the syphilitic all syphilis, etc., and also in the same manner as the pyogenic wound separates all pus. Pyæmia is constituted; centres of multiple suppuration are created under ordinary innocuous and common influences.

Virchow, in 1846, undertook to prove that purulent infection, in the literal sense of the word, does not exist. He maintained that the venous coagula of inflamed veins did not become purulent, but puriform. In 1847, passing to the examination of pyæmic blood while in circulation, and relying upon the identity of leucocytes and the white globules of pus, he attributed to an accumulation of leucocytes the appearance of blood described as pyæmia. In 1854, he demonstrated, taking in part, at least, the arguments of Cruveilhier, that the absorption of the pus-globules, entire and intact, was an impossibility, and that there is no other method of entrance of pus into the blood than by an open vessel. Gulliver, of the English army, had already stated that the puriform mass in the interior of clots does not originate in the walls of the vessel or clot, but is produced by transformation of the central layers of the clot. On microscopical examination he determined that the fluid in these clots did not contain pus.

With these facts as the basis of inquiry, viz., that the character of the contents of these clots is puriform, but not purulent, and is composed chiefly of granules, Virchow pursued the inquiry as to the final disposition of this material. It was found that these clots or thrombi finally soften, disintegrate, and the contents escape into the circulation. Virchow demonstrated the embolic character of certain products, previously thought to be inflammatory in their origin, found in the form of white, fibrine-like masses in the spleen and other organs. He was of the opinion that metastatic abscesses in the lungs were always embolic; in cases of puerperal fever, with multiple abscesses in the lungs, he alleged that thrombi or clots were always found in the pelvic vessels.

In 1850, Henry Lee performed the following experi-

ment: Perfectly pure blood, recently drawn from a vein, was mixed with pus; the result was, in his opinion, a more rapid coagulation of the blood and a firmer clot. Considering the fact of the frequent obstruction of inflamed veins by a coagulum, he concluded that the coagulation of the blood under the influence of the pus ought to be the first link in the chain of the morbid process of pyæmia. According to this theory, the presence of pus has the effect of thickening the blood, so that it is incapable of pursuing its course through the capillaries, and adheres to their walls, and transforms them into so many inflammatory centres and purulent dépôts. This doctrine obtained some credence in England, but it was intrinsically without merit.

In 1851–52 Henry Bennett noticed the resemblance between pyæmia and leucocythæmia. The resemblance was found in the identity of form and constitution existing between pus-globules and the white globules of the blood, an identity to which Donné had drawn attention in 1844.

In 1853 Dr. W. Jenner,[2] of London, attributed the multiple abscesses which follow acute specific diseases to a condition which he termed *pyogenic fever*. These abscesses were believed to be due to the diseased state of the blood. The opinions of Jenner were in accord with those previously advanced by Tessier in 1838, under the title *purulent diathesis*, which he regarded as a tendency to suppuration in the solids and coagulable fluids. Bennett[3] discussed the subject under the name *ichoræmia*.

The theory that infectious diseases are produced by micro-organisms, had long since been suggested, but in 1831 Braconnot announced the doctrine that the virulent principles are the ferments. This doctrine was based upon the fact that agents which arrest fermentation also destroy the virulent properties of the infectious liquids. In 1836 Donné discovered microscopic organisms in the pus of chancres which were not found in ordinary pus, and to which he attributed its virulence. In the following year Beauperthuis and Adet de Roseville proved the existence of micro-organisms in the pus of chancre, and in 1838 the same authors advanced the opinion that these animalcules were the cause of fermentation. In 1841 Raciborski noticed the resemblance between the development of the pustules of variola and the viscous foci and phenomena of fermentation. In the one as in the other, a minute particle of a body placed in given conditions, mingles in a mass of liquid which contains these elements, and produces a movement of decomposition, the result of which is the reproduction of a material of the nature of that which was the first cause of the movement. Comparing surgical multiple abscesses with pustules of variola and viscous foci, he felt justified in presuming that the explanation was the same for visceral abscesses. The qualities of the liquid which they contain prove in some degree their origin, and render it probable that they owe their existence to the special action of pus on the blood. But in order to produce such a remarkable modification of the mass of the blood, it is necessary that there should be a state of decomposition, as laudable pus does not produce any similar change. He, therefore, considered the action of putrid pus on the blood as absolutely comparable to fermentation, and this was, in his view, the secret of purulent infection.

In 1848 Fuchs mentioned the presence of bacteria in certain septic diseases in animals, and, in 1850, Davaine reported having discovered vibriones in a quiet state in the blood of sheep inoculated with the blood of other sheep affected with splenic fever. In the same year Pollender discovered an infinite number of rods in the blood and sanguineous extravasations of cattle dying of charbon. Many other observations were made previous to 1861, when Pasteur began his demonstrations; all were confirmatory of the existence of micro-organisms in the blood, after the injection of purulent fluids, and in certain infectious diseases.

Pasteur first demonstrated the fact that butyric fermentation has as its agent an organism, a *vibrion anaërobie* (one living without free oxygen). He next (1862) proved that in the atmospheric air there exists an innumerable multitude of organized corpuscles, which are the germs of fermentation. In 1863 he brought forward his researches upon putrefaction before the Académie des Sciences of Paris. He stated that putrefaction was determined by organized ferments of the vibrio species; these vibrionic ferments of putrefaction are all *anaërobies;* in a closed vessel putrefaction does not begin to be manifested by external signs until after a certain lapse of time, at least twenty-four hours. During this first period there is a process going on which leads to the disappearance of the oxygen gas in the putrefiable material, and its replacement by carbonic acid. If, however, the medium is neutral or alkaline, the process is effected under the influence of small infusorial *aërobies*, which live by consumption of free oxygen, notably the *monas corpusculum* and the *bacterium termo*. When the oxygen has disappeared, these animalcules perish and are precipitated to the bottom of the vase. If the liquid is free from the germs of putrid fermentation, the whole remains indefinitely in the state of rest.

Pasteur, therefore, regarded putrefaction as a fermentation ending in the reduction of putrescible matters. He distinguished two phases or periods. In the first period, under the influence of ferments due to anaërobies of the vibrio kind or genera, there occurs a transformation of azotized matters into more simple, but still complex, products. In the second period these last products are, in their turn, reduced to binary compounds of more simple form, by the action of infusorial agents of the aërobic kind (bacteria, mucosa, etc.).

The theory of germs applied to pathology was, in effect, the application to morbid processes of the doctrine of putrefaction advanced by Pasteur. At first the discussion arose upon its application to *charbon*, or splenic fever. The bacterial origin of this disease, suspected by Davaine (1850), then by Pollender (1850), and Brauel (1856–57), was demonstrated in 1863–64 by Davaine, who established the fact that when we inoculate with the blood of an animal affected with charbon and charged with bacteria, the animal inoculated is infected, and bacteria are reproduced and multiplied in the blood.

The generalization of this idea of the origin of charbon to other infectious diseases rapidly followed. In 1863 Signol had already announced the presence of bacteria in the blood of horses affected with typhus. But in regard to septicæmia and pyæmia, investigations seemed, on the contrary, to prove at first that they were not due to the presence of micro-organisms. Pasteur was the first to advance the opinion that septicæmia had a parasitic origin. In 1866 Coze and Feltz published their observations on the presence of infusoria and the state of the blood in infectious diseases.

The fact was clearly established in their minds that bacteria constitute the septic poison. In 1872 Burdon Sanderson, of London, advanced the opinion that in pyæmia there is a special poison which does not exist in septicæmia. As to the nature of the poison, this physiologist discovered that the pyæmic pus contained bacteria of a particular character, and the number seemed to be in proportion to the toxic activity of the fluid.

In the same year Klebs affirmed the identity of septicæmia and pyæmia, and attributed them to changes in the pus due to a special agent, which he designated as the *microsporon septicum*. He contended that this micro-organism has a peculiar power of penetration and destruction; it penetrates with facility the tissues and excites a process of molecular necrosis; it causes ulceration of the vessels and thus produces secondary hæmorrhages, called septic. He believed it enters the lymphatics, and that after it has reached the veins the spores accumulate around the valves, determine inflammation of the internal membrane and a consecutive thrombosis which becomes the source of emboli. Thus the *microsporon septicum* creates metastatic abscesses, either by its own peculiar local influence, or by creating thromboses.

In 1872 Davaine brought before the Academy of Medicine of Paris, a communication on septicæmia in which he contended for the progressive virulence of septicæmic blood; according to his experience the millionth, or even the trillionth, part of a drop of septicæmic blood pos-

sesses a virulence which quickly destroys a rabbit inoculated with it. He explained that the progressive virulence depends upon the reproduction and multiplication of the septic virus, which is otherwise identical with the ferment of putrefaction. The deduction which he drew from his experiments was, that septicæmia is a putrefaction effected in the blood of a living animal by the same process, and by the same agents, as putrefaction is effected in the free air, viz., by the activity of vibrios. He attributed to this cause the cadaverous odor of persons dying of septicæmia and the rapid decomposition of their bodies. The discussion which this paper elicited led to a renewal of experiments by a large number of scientific investigators, and though many of the details were disputed, there was unanimity of opinion in regard to the essential facts. The general conclusion was that in septicæmia the toxic and active agent is of an organic nature, and is a bacterium; that the disease is closely allied to putrefaction, and the process which takes place is analogous to that of putrid fermentation. The bearing of these facts upon the subject of pyæmia, and in particular upon the general accidents of an infectious and septicæmic nature occurring in this malady, is undoubted.

The symptoms produced in the animal were believed by Panum to be due to a chemical substance produced by these micro-organisms, and not to their multiplication in the blood and tissues. Bergman reports experiments in which he claims to have detected a crystalline substance which he called "sepsin." Subsequently (1873) Bergman modified his first statements, for he discovered that when putrid matters were deprived of bacteria by a process of filtration, they lost their poisonous properties, or maintained them in a very limited degree. He concluded that if sepsin is alone efficacious, it attaches itself to bacteria, and it is to sepsin that the bacteria owe their toxic properties. This confession evidently tended to confirm the original theory that the poison is inherent in bacteria.

In 1873, Samuels contributed a paper to the general subject, in which he recognized three phases in the series of septic accidents, to each of which he referred a special variety of infusoria. The effect of these organisms was as follows: 1, *phlogogenous*, or to excite an inflammation; 2, *septogenous*, or to give rise to the putrid or infectious phenomena observed upon the living organism; 3, *pyrogenous*, or to cause fever and suppuration. From his experiments he believed that the following division of micro-organisms might be made: 1, The bacterium termo was phlogogenous; 2, spores, collected in the form of a rosary, and vibriones, were septogenous; 3, bacteria (unnamed) larger and more brilliant than bacterium termo, were more especially pyrogenous.

Koch[6] concluded from his experiments that the pathogenic bacteria consist of different species. To prove that he did not stand alone in this view he quotes Cohn as stating that, in spite of the fact that many dispute the necessity of separating bacteria into genera and species, he separates bacteria of different form and fermenting power from each other. Eidam, also, came to the conclusion that different forms of bacteria require different forms of nutriment, and that they behave differently toward physical and chemical influences. Koch was able so to isolate and cultivate two different species in mice, as to determine their special infective power.

Is septicæmia the result of the action of ptomaïnes or of microbes? was the question which Jeannel and Laulanié attempted to answer. Ptomaïnes can pass through the layer of granulations lining a wound, since they are in a state of solution, while microbes cannot enter the circulation unless a solution of continuity exists. Now, as septicæmia is only observed when a break in the continuity of the living membranes of a wound exists, the authors attribute to the effects of ptomaïnes a subsidiary part, while the principal function is performed by microbes.

Petrone[9] experimented on the blood and serum from all the tissues of patients dying from virulent septicæmia. One portion of the blood and serum was injected unaltered under the skin of rabbits. Another portion was boiled and thoroughly filtered before injection, and a certain quantity of the same fluid boiled was introduced into clean disinfected tubes containing a little beef-broth, and then closed, hermetically sealed, and placed in a warm situation. All of the animals presented the same symptoms, and all died; the necropsy showed the same lesions in all, and the same micro-organisms in the blood, serous, and intestinal fluids. The blood of all of these animals caused death when injected into other rabbits. The blood in the tubes did not become turbid. The conclusions are that in septicæmia the bacteria are not a primary, but rather a secondary, fact, and that the virus of septicæmia is probably represented by a chemical poison; in other words, the bacteria acquire their virulent property through a chemical ferment contained in the septic fluid. This conclusion, the author believes, suggests the pre-existence in the animal organism of ordinary schizomycetes, innocuous, but which in the presence of septic poisons become transformed into pathogenic bacteria, and the fact, experimentally demonstrable, that the bacteria only are able to develop in the animal organism the poison in question. Of these two consequences he holds that the first is the most acceptable and most logical (*London Medical Record*).

Results of Investigations.—The preceding sketch briefly outlines the course of investigations into the etiology of the complications of wounds, but it gives a very meagre view of the vast amount of labor which has been expended upon this subject, especially during the present century. These studies have been undertaken and vigorously prosecuted by the most eminent physiologists, pathologists, and scientists of every period. In the early history of these investigations speculation took the place of experimentation, and the most absurd theories were advocated. As pathological inquiries advanced in importance and accuracy more rational theories prevailed. When, finally, experimentation was adopted as the basis of forming an opinion, a new impulse was given to these investigations, and far more accurate views began to prevail. At length came the revelation of the power of micro-organisms to establish morbid processes in the animal system, and their presence in the pus in septicæmia and in the abscesses of pyæmia seemed to determine at once the true nature of these affections. But it is apparent, from the more recent literature of this subject, that, while there is a consensus of opinion as to the potential force of micro-organisms in initiating the morbid processes, there is still a wide divergence of opinion as to the details of their operation. The tendency evidently now is toward a belief in the multiplication of the pathogenous bacteria, and their division into species, each having its special morbific power. In regard to the nature and action of bacteria, it is held (Ziegler, "Path. Anat.") that the factors which determine the invasion and the course of development of bacteria within the human body are two. On the one hand, the bacteria must be endowed with certain vital properties of a special kind; on the other hand, there must be a predisposition on the part of the system. Slight chemical changes in the constitution of a tissue often enough determine whether a given bacterium can develop in the tissue or not. In many cases, bacterial invasion depends on the formation of a local necrosis or wound, in which the fungus can settle and develop; in other cases some grave disturbance of the circulation may lead to a failure of resistance on the part of the tissue. Many bacteria can only come to development within the human body on rare occasions, as their usual habitat is without it; others only meet with fit conditions for their existence and growth within the body, and do not multiply without. These micro-organisms (Cheyne) grow on various soils, though some are more particular than others; the substances essential for their nourishment are water, phosphates, salts of potash, carbonaceous and nitrogenous organic substances; most forms require free oxygen, or grow much more rapidly in it, but there are some which will not live unless oxygen is almost or entirely absent. As the result of their vital action these bodies produce extensive alterations in the materials in which they grow; they break up the complex organic com-

pounds, and reduce them to simpler forms; in this way the effects are slight and transient; if the wound is larger, as when it is left to heal by granulation, the absorbed material gives rise to fever, which is called traumatic; and again, the wound may be so large and the absorption of the poison so rapid as to cause fatal symptoms. This is called septic intoxication.

It is maintained (Lister, Cheyne) that while the products of the growth of certain bacteria give rise to general effects—traumatic fever and septic intoxication—they also act locally on the wound and cause inflammation and suppuration. Though inflammation and suppuration in a wound may be due to other causes, yet the chief causes are the growth of micro-organisms in the discharges from the wounds, or in the tissues. They grow in the walls of the wounds, and give rise to irritating products which keep up the inflammation and suppuration; they often cause extension of the inflammatory process, or burrowing of the pus, and sometimes, spreading into the neighboring tissues, they give rise to the formation of abscesses. When the pus of an acute

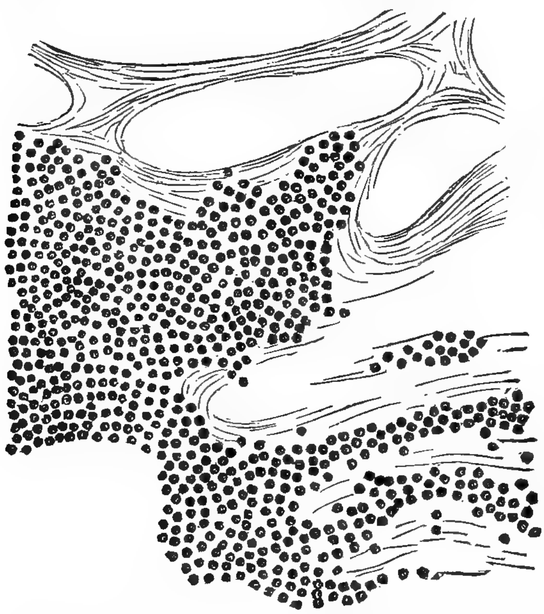

FIG. 3448.—Grouped Micrococci Invading Abscess Wall. (Ogston.)

abscess is examined micrococci are always found in it, sometimes in large numbers.

An illustrative example of the growth of micro-organisms in the tissues is seen in erysipelas. If portions of the spreading margin of the redness and of the healthy skin in the immediate vicinity be excised and cut into sections, it will be found that in the healthy skin, immediately beyond the red margin, the lymphatic vessels contain large numbers of a minute micrococcus frequently arranged in chains. At the red margin itself there are inflammatory appearances as well; the lymph-vessels contain not only micrococci, but also numerous leucocytes, and there is a small-celled infiltration around them and in the skin; the micrococci also extend into the lymph-spaces. Inflammation and suppuration may be caused (Ziegler), not merely by growth of micro-organisms in the discharges of the wound, but also by growth of micro-organisms in the tissues (Fig. 3448). This effect is only caused by certain micro-organisms, for, on the one hand, many micro-organisms will not grow in the living blood or tissues, but yet, growing in the discharges, can produce irritating materials, and cause suppuration; while, on the other hand, many micro-organisms grow in the living tissues without causing suppuration. The micro-organisms which grow in the living tissues and cause suppuration belong, so far as is known, almost entirely to the group of micrococci; they cause fermentation and decomposition of organic substances. In some instances, well-known chemical substances are formed, and the agency of the micro-organisms is extensively employed in the manufacture of various articles of food and drink; in other cases, however, the substances which they produce are extremely poisonous, and when injected into animals cause symptoms of poisoning resembling the effects of various alkaloids.

Some micro-organisms can grow in the animal body, giving rise to a variety of diseases; some are fatal to most animals, and others are only pathogenic in certain species of animals. The diseases caused by the growth of these bodies in the blood and tissues are grouped together under the term "infective diseases," of which there are two kinds, viz., those in which the infection occurs from a wound or open surface—the traumatic infective diseases,—and those in which no wound is necessary, and where the pathogenic organisms are supposed to be able to enter the body through the unbroken surface.

Some micro-organisms produce such alterations in organic fluids that the injection of these fluids into animals is followed soon after the injection by symptoms of poisoning, and if in sufficient quantities, by fatal results. If the quantity of poison is slight there is a moderate elevation of temperature, which soon subsides; if the quantity is greater the fever is higher and more prolonged; but if there is a fatal dose the temperature soon sinks below the normal, sometimes accompanied by vomiting and diarrhœa. The clinical expression of these facts is as follows: Where a wound is small and but a very limited amount of infection enters the system, the traumatic fever is absent or light; if a large amount is absorbed the fever is more or less severe, according to the amount; a sufficient amount may be absorbed to prove fatal at once.

It may be stated as a conclusion that two theories have chiefly prevailed as to the introduction of bacteria into the animal system, and their action.

The first theory explains their action as primarily in the wound, where they set up chemical changes which result in the formation of a poison originally called "sepsin" by Bergman. This poison, absorbed into the circulation, induces fever or septic intoxication. Under favorable circumstances coagulation of the blood occurs, and thus gives rise to thromboses. From these clots arise emboli which clog the small vessels of organs, and result in abscesses.

The second theory attributes to the direct action of the micro-organisms, first on the wound, and second on the blood and tissues, the symptoms of septicæmia and pyæmia.

The latter theory is more generally accepted. According to this doctrine,[6] non-pathogenous bacteria exist in the healthy organism in large numbers, and subsist upon substances accessible to them; the result of their action is the occurrence of chemical changes in these substances. If the organism is in a normal condition these changes are not harmful, or are quickly eliminated from the system. But pathogenous bacteria have the power of settling in living tissue; all that is necessary is that a bacterium should reach a spot that affords the conditions requisite for its development; it then multiplies and forms colonies or swarms; these may, according to the species of the fungus and the nature of its soil, remain in aggregations forming heaps or masses, or may spread through the tissues. The bacteria may force their way into the substance of the constituent elements, and especially into the tissue-cells, which are sometimes found to be crammed with bacteria. The cells attacked by the fungi often appear quite uninjured, or they may be altered; the epithelial cells swell up and liquefy or degenerate into flaky, homogeneous lumps, or turbid, denucleated masses; often they break down into granular detritus; the nucleus is broken up, or swells and disappears; the fibrous elements of the connective tissue degenerate like the epithelial cells; the ground-substance undergoes a change at the same time, becomes turbid, loses its structure, and ultimately dissolves. The inflammatory process set up by

bacterial action may be of very different intensity and extent in different cases; it may be slight and transient, or it may be severe and terminate in suppuration and necrosis; occasionally a more or less perfect granulation-tissue is formed as a result of the inflammation. Again, this inflammation often results in a great aggregation of living cells in the affected tissue, and these may so act as to repel the continued advance of the fungi, which soon perish, and the result is healing and cicatrization. The fixed tissue-cells of the region may also act so as to check the development of the bacteria; if this happen the bacterial invasion continues to advance; they first enter the surrounding tissues, passing along the natural lines of division, then they break into the lymphatics, and often into the blood-vessels also. If they can live in lymph or blood they go on multiplying; if not, they perish; many bacteria, like the micrococcus of erysipelas, flourish best in the lymphatics; others, like the anthrax bacillus, are more at home in the blood.

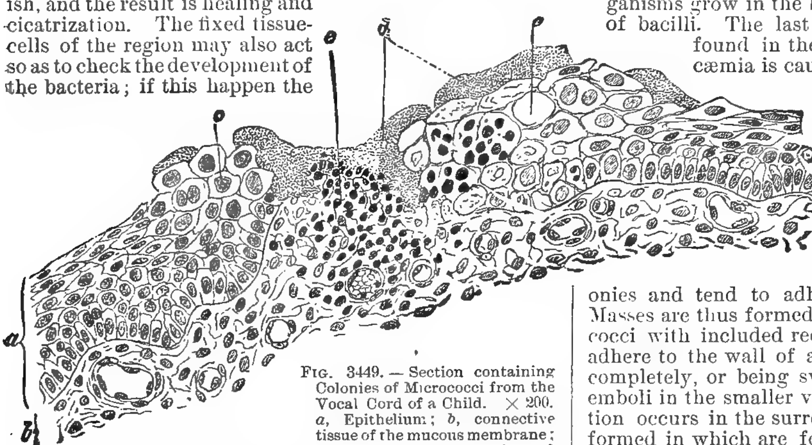

FIG. 3449. — Section containing Colonies of Micrococci from the Vocal Cord of a Child. × 200. *a*, Epithelium; *b*, connective tissue of the mucous membrane; *c*, swollen, degenerated, and denucleated epithelial cells; *d*, layer of micrococci; *e*, inflammatory small-celled infiltration of the degenerated epithelium and of the fibrous structures. (Ziegler.)

They reach the blood either through the lymphatics or directly; in the latter case the walls of the veins in the invaded region are penetrated by the micro-organisms, or they pass into the veins from the capillaries; once in the current they are carried on by it to remote parts; many perish in the blood, others again increase and multiply. Of the last some, as anthrax bacillus, thrive best in blood that is in motion; others, as tubercle bacillus and pyæmic micrococcus, prefer blood that is at rest, and only grow when they come to a standstill in some venule or capillary. The tissue changes are the slightest in the case of bacteria which circulate and multiply in the blood (Fig. 3450). Bacteria which settle in the smaller vessels give rise to various forms of degeneration (Fig. 3451), necroses, inflammations, and hæmorrhages.

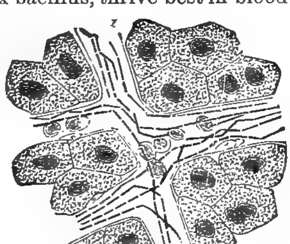

FIG. 3450.—Micro-organisms in the Circulating Fluid. (Ziegler.)

The Nature of Septicæmia and Pyæmia.—The application of these facts to the explanation of the symptoms of these affections has been variously made by writers. This difference of opinion is due to the inherent difficulty of accurately determining the nature of the symptoms and pathological conditions which exist, their order of sequence, and the ultimate relation of micro-organisms to these obscure phenomena. The tendency now evidently is to regard both septicæmia and pyæmia as diseases having many forms. Cheyne remarks: "Septicæmia is a complicated affection, and probably arises under several circumstances; continued absorption of the poisonous material from wounds will keep up a feverish state with all the symptoms of septicæmia, and if long continued may terminate fatally; in other cases the micrococci grow in the tissues of the wound, and pour their products or ptomaïnes, as they are called, into the blood; here micrococci may be found in the blood, but the essential seat of disease is the tissues. In a third form micrococci grow in the blood, and multiplying there, give rise to the symptoms. In a fourth form organisms grow in the blood, but they belong to the class of bacilli. The last two cases correspond to what is found in the lower animals. In them septicæmia is caused by more than one form of organism growing in the blood, and giving rise to symptoms and post-mortem appearances which can only be classed together as septicæmia."

Pyæmia in rabbits (Koch, Cheyne) has been shown to be due to the growth of micrococci in the blood. These cocci are very minute; they grow in colonies and tend to adhere to the red blood-corpuscles. Masses are thus formed composed of colonies of micrococci with included red corpuscles. These masses may adhere to the wall of a blood-vessel, grow and block it completely, or being swept on in the circulation, form emboli in the smaller vessels. In either case inflammation occurs in the surrounding tissue, and an abscess is formed in which are found numerous micrococci. The inoculation of another animal with the pus from these abscesses, or of the blood containing the micrococci, is followed by the reproduction of the disease.

Koch employs the term "traumatic infective diseases,"[7] and states that he applies it to "a group of affections formerly known as traumatic fever, purulent infection, putrid infection, septicæmia, pyæmia, but which were included at a subsequent period (when the view became generally accepted that these diseases were essentially of the same nature) under the title 'pyæmic or septicæmic processes.'" The similarity of the two affections is noticeable in the fact that, though pyæmia was alone thought to be characterized by metastatic abscess, yet a more careful study showed isolated, microscopic, metastatic deposits in cases which had all of the characteristic symptoms of septicæmia. Birch-Hirschfeld defines septicæmia to be a disease due to alterations of the blood, as the result of the absorption of the products of putrefaction; while pyæmia is due to a general infection derived from the surface of a wound or from a centre of primary suppurative inflammation, caused, probably, by micro-organisms and not by putrid infection.

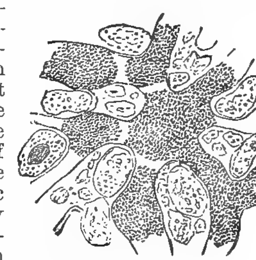

FIG. 3451.—Micro-organisms in Stagnant Blood. (Ziegler.)

Billroth's definitions are, in general, more useful for clinical studies. He remarks ("Surgical Pathology"): "By septicæmia we understand a constitutional, generally acute disease, which is due to the absorption of various putrid substances into the blood, and it is thought that these act as ferments in the blood, and spoil it so that it cannot fulfil its physiological functions." "Pyæmia holds the same relation to simple inflammatory and suppurative fever that septicæmia does to simple primary traumatic fever; it is symptomatologically characterized by intermittent attacks of fever, and in its pathological anatomy by the frequency of metastatic abscesses and metastatic diffuse inflammation."

The Committee of the Pathological Society of London, in their report on the nature and causes of those infectious diseases known as pyæmia, septicæmia, and purulent infection, accept the conclusion that there are two distinct forms of septicæmia. One form occurs when putrid blood is injected subcutaneously, no organisms ap-

pear, and the disease cannot be transmitted by inoculation; this is septic intoxication. In the other form the poison has been injected, and organisms appear abundantly in the blood, and are very virulent. The committee make ten groups of pyæmia, viz.: 1, Pyæmia secondary to an open wound, but without evidence of embolism; 2, venous thrombosis as a secondary affection; 3, venous thrombosis and softening of thrombus without embolism; 4, venous thrombosis and softening of thrombus with secondary abscesses in other viscera, but not in the lungs; 5, venous thrombosis with softening and abscesses in the lungs and other viscera; 6, venous thrombosis, softening of thrombus, and embolic abscesses in the lungs; 7, pyæmia secondary to infective periostitis; 8, pyæmia secondary to infective endocarditis; 9, infective myositis; 10, spontaneous septicæmia and pyæmia.

Symptoms.—The symptoms in well-defined cases of septicæmia and pyæmia following wounds, are accurately given in the extracts from Billroth's work. The chief distinction there made between these two forms of wound complication is based upon the pathological conditions long since established, viz., the existence (pyæmia) or non-existence (septicæmia) of multiple abscesses. This distinction is undoubtedly still the most convenient and most accurate in practice, as the symptoms vary in no small degree according to the presence or absence of this element in each case. For practical clinical purposes the relations of these wound complications have been clearly set forth by Billroth in the illustrative cases quoted at the commencement of this article. To those cases, therefore, we refer as embodying the order of symptoms of those "general accidental diseases which may accompany wounds and other local inflammations."

Diagnosis.—The diagnosis of septicæmia and pyæmia, when these affections develop in regular order after wounds or injuries, is not difficult. They may, however, occur under circumstances which render the diagnosis very difficult, and this is especially true when there has been no antecedent wound. The symptoms are often so masked as to lead the observer quite astray. The diseases which are most liable to be taken for both of these affections are enteric fever, typhus, inflammation of the kidneys and bladder, acute rheumatism, etc.

Wagner ("On Occult Septicæmia," *London Medical Record*, February 15, 1882) regards septicæmia as much more frequent than is generally believed. He is of the opinion that, in consequence of ignorance of its symptomatology, many cases are overlooked. He formulates its symptoms thus: 1. The general condition is serious; there is a febrile state, suddenly apparent, rarely preceded by a regular rigor, but attended with much shivering, and very often with severe rheumatoid pains of the bones and joints. 2. The patient experiences so much discomfort that he is obliged to take to his bed at once, or, at the latest, after some days. 3. There is violent fever of the remittent or intermittent type, but always irregular; the exacerbations usually assume the aspect of a severe rigor. 4. The pulse is very frequent, usually dicrotic. 5. There is frequency of respiration, which cannot be explained by the mere elevation of the temperature, and which, in the majority of cases, is connected with serious affections of the lungs or pleura. 6. There is hypertrophy of the spleen, with scarcely any appreciable increase in the size of the liver. 7. There is more or less marked abdominal meteorism, often accompanied by intestinal borborygmi, occasionally by frequent fluid stools. 8. There is moderate albuminuria, rarely tube-casts or blood-corpuscles in the urine. 9. There is a pustular or papular cutaneous exanthem, with a hæmorrhagic basis. 10. Icterus is rarely intense. 11. Subjective and objective symptoms are met with in the large articulations and the long bones, especially rheumatoid pains, occasionally attended with swelling or redness of the joints. 12. Serious cerebral symptoms occur, such as delirium, convulsions, and coma. 13. The progress of the affection is rapid. 14. Medicinal treatment by quinine, the salicylates, etc., is unsuccessful.

The affections with which septico-pyæmia may be confounded are more especially typhoid fever, of which the progress is very much less rapid and less tumultuous, and which is never accompanied by icterus or by an exanthem similar to that described, nor by joint lesions; miliary tubercle, which it is almost impossible to diagnose; and epidemic cerebro-spinal meningitis, which presents, perhaps, still greater difficulties, since the rapidity of the progress and the presence of an exanthem can no longer be considered as means of diagnosis. The question is still further obscured by the fact that the wound does not always exist, and that in place of it there may be internal suppuration, necessarily overlooked because it does not give rise to any characteristic symptoms. In a certain number of cases it has been impossible to find any starting-point, notwithstanding the certainty that pyæmia existed.

Wunderlich, in 1857, described some cases as primary pyæmia; Schutzenberger also spoke of cases of this kind, and recommended careful examination of the scalp in cases of acute fever. Cases of pyæmia without any discoverable lesions have been reported (Cavafy, Whipham, Dickinson, *London Lancet*, June 26, 1886). In three cases autopsies were made and multiple abscesses were found, but no lesions were discovered through which the poison could have entered the system.

Treatment.—The discovery of the etiological relations of micro-organisms to suppuration opened a new and most important field of inquiry. The question now arose, can these germs be destroyed without complicating the wound, and, if so, what is the most useful agent? In determining this question we must acknowledge the great services to practical and scientific surgery of Sir Joseph Lister. We would not detract from the merits of a long line of earnest students who so faithfully labored in this field of experimental pathology, many of whose works were so often apparently unproductive. Even their errors often led to new and more successful efforts, and hence added, though indirectly, to the total sum of knowledge necessary to the final, complete elucidation of this most obscure subject. But in these later times no one has so intelligently and so perseveringly striven to apply the knowledge gained as to the correct etiology of septicæmia and pyæmia, and as to their prevention.

The methods of preventing these diseases are fully discussed in the article on Antiseptics, and need not be noticed here. When they do occur the treatment should be directed, first, to the entire removal of the source of putrid material, and second, to sustaining the patient's strength. It is now possible, by evacuating and cleansing abscesses, by the removal of carious bone, and by the disinfection of sources of putrid emanations, to remove at once the cause of both septicæmia and pyæmia.

Stephen Smith.

[1] Aitken: Sci. and Prac. Med., vol. ii., p. 738.
[2] Gulstonian Lectures delivered at the Royal College of Physicians in London, Med. Times and Gaz., 1853.
[3] Principles and Practice of Medicine.
[4] Traumatic Infectious Diseases.
[5] Experimental Researches on Septicæmia, 1884.
[6] Ziegler, Path. Anat.
[7] Investigations into the Etiology of Traumatic Infective Diseases, The New Sydenham Society, 1880.

SEVEN SPRINGS. *Location*, Washington County, Va. *Post-office*, Glade Spring, Washington County, Va.

Access.—By the Norfolk & Western Railroad to Glade Spring, thence two miles to the springs; or to Saltville, thence five miles to the springs.

Therapeutic Properties.—Their medicinal properties are tonic, alterative, diuretic, antiperiodic.

These springs, seven in number, are situated in Washington County, in the southern part of Virginia, amid the Blue Ridge Mountains, famed for their beautiful mountain scenery. The waters of the springs are evaporated, leaving the solid ingredients, which are bottled and sold throughout the country as "the Seven Springs Iron and Alum Mass."

Analysis (by J. W. Mallet, M.D., Chemist).—The mass appears as a stiff dough, or soft solid, of light gray color, and marked acid reaction to test-paper. The contents of several bottles having been thoroughly mixed, the follow-

ing composition was found for the mixture in one hundred parts:

Aluminium sulphate	15.215
Ferric sulphate (persul. iron)	4.628
Ferrous sulphate (protosul. iron)	0.412
Nickel sulphate	0.162
Cobalt sulphate	0.014
Manganese sulphate	0.257
Copper sulphate	0.008
Zinc sulphate	0.301
Magnesium sulphate	16.006
Strontium sulphate	trace
Calcium sulphate	17.538
Potassium sulphate	0.060
Sodium sulphate	0.226
Lithium sulphate	0.019
Ammonium sulphate	0.022
Sodium chloride	0.326
Calcium fluoride	trace
Calcium phosphate	trace
Silica	1.504
Organic matter	0.123
Water	42.938
	99.759

G. B. F.

SEWAGE, DISPOSAL OF. Under this heading will be considered not only the disposal of the contents of sewers, but also the other methods of disposing of the refuse products of households and communities.

In using the term "disposal" we may avoid confusion if we distinguish between immediate disposal, on the premises, of refuse matters as they are day by day produced, and the ultimate disposal by which they are rendered innocuous by utilization or removal, or both.

I shall describe, first, the methods employed for immediate disposal; secondly, those for ultimate disposal; and, lastly, shall compare the merits of the various systems and their relative adaptability to the needs and circumstances of cities, villages, and isolated houses.

I. The Modes of Immediate Disposal at present in use may be classified as follows:

1. The privy-pit and privy-vault.
2. Dry methods.
3. The water-carriage system, or wet method, as it is sometimes called.
4. Pneumatic systems.

1. Privy-pit and Privy-vault.—It is hardly necessary to describe the privy-pit system, if indeed we should apply the term "system" to such a crude and barbaric device as an excavation in the earth for the reception and storing of filth. I shall endeavor to do a certain measure of justice to its demerits and their results in their appropriate place, in the last division of this article.

In the privy-vault a slight improvement is made on the pit by placing in the excavation a water-tight cask, tank, or receptacle, made of cement, masonry, or other material. By these means it is intended to prevent soaking of the filth into the soil, but the receptacle often becomes leaky.

In places where these pits and vaults are allowed to exist removal is effected in various ways, the most primitive being by carts, sometimes with a boarded cover, sometimes with a layer of ashes or earth spread over the night-soil. In other places removal is made by means of some form of "Odorless Excavator." These machines act on the principle of the exhaust-pump: the contents of the privy or cesspool are drawn into a tank upon wheels; or they may be transferred to detached barrels, thus obviating the necessity of keeping the pump idle while the night-soil is being conveyed away, and also affording greater facility of transportation. The apparatus for the latter is more complicated, of course, than that of the "tank" method; from a description of this barrel-system (Fig. 3452) the principle of the other may readily be understood. The small hand-pump seen in the foreground is for alternately exhausting and compressing (as may be required) the air in the pump-receiver *B*. The little furnaces *H* and *L* are for deodorizing the air displaced from *B* and *O*, respectively. These latter are strong oak casks. The suction hose, *C*, is lined with a spiral, flat, galvanized iron or brass coil to keep it from collapsing, should anything obstruct its lower end during the process of exhausting the air from *B*. The following extract from Ames' description of the "Eagle Odorless Excavating Apparatus," will explain its other parts and mode of action:

"Lift the gate *a*, on pump-receiver *B*; see that the lower gate *b* is shut tight. Work the brakes, when the air will be exhausted from the receiver via the throat-valve opening and air-hose, *f v*. The contents of the vault will at once rise through the suction-hose, *C*, into the receiver, till the material lifts the cork float-valve and stops the pump, the receiver being full. Instantly shut the upper gate, *a*. The foul air exhausted from *B* has passed through the pump and short air-hose, *k*, under the fire to the deodorizer *H*, and is consumed.

"To transfer the material to the barrels or tank on the wagon, uncouple the end of air-hose, *G*, from the suction-spud of the pump. Remove the free end of air-hose, *k*, from the throat of the deodorizer, and couple the ends of *k* and *G* together.

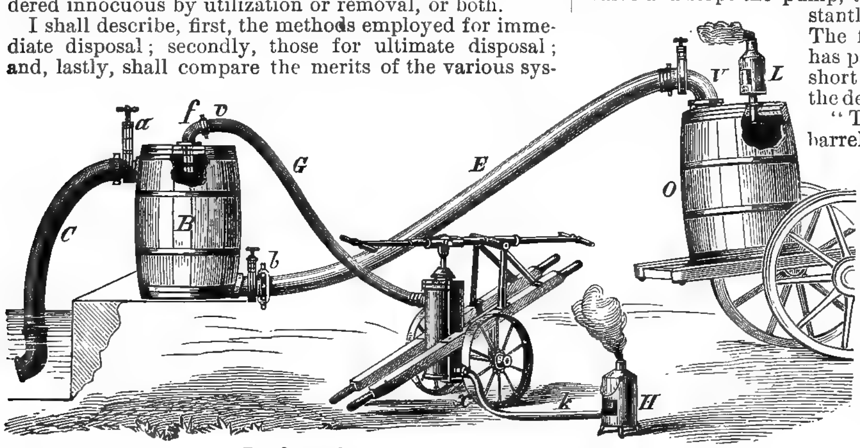

Fig. 3452.—Odorless Excavator Barrel System

"Have goose-neck valve *V*, on the wagon-barrel, lifted. Lift lower gate, *b*, on receiver, and work the brakes, when the compressed air, driven in at the top of the receiver, will rapidly force the contents through the leading hose into the wagon-barrel. When the wagon-barrel is full, its float-valve will be lifted, and the roar of the wagon-deodorizer, *L* (which has consumed the foul air forced from the barrel), will cease. The goose-neck valve, *V*, and deodorizer, *L*, may now be coupled with the next wagon-barrel, and the process resumed as described. If a long line of leading hose is used, it will be necessary to reserve one wagon-barrel for its contents, or it may be returned on itself, and the contents discharged into the vault."

A method which is in operation in some places is to fill a strong metal cylinder with steam; this condenses on the way to the scene of operation, creating a vacuum; one end of a hose is attached to the cylinder, the other being lowered into the vault; a valve in the coupling of the cylinder and hose is now opened and the contents of the vault are drawn into the cylinder.

In another method a vacuum is produced by the revolution of the wheels of the wagon on its way to the vault which is to be emptied. This method is in use in Chicago.

It is nearly always necessary to complete the emptying by means of the shovel, owing to the presence of sticks, tin-cans, or other rigid bodies. It would be desirable, also, to cleanse the besmeared surface of the vault with a solution of corrosive sublimate or other deodorant.

2. Dry Methods.—These may be divided into (*a*) the dry-earth and dry-ash systems; (*b*) the various midden systems; (*c*) the pail systems; (*d*) dessication.

(*a*) *In dry-earth and dry-ash systems*, dry earth or dry ashes are mingled with the fæces in sufficient quantity to absorb all moisture from them, to render them inodorous and to prevent decomposition. The earth should be well dried in the sun, or by artificial heat, and then stored in a dry place. It should contain no lumps, and it is better that it should be sifted or screened so as to form a very fine powder. The earth best adapted is a clay loam; sand and gravel are of no use for the purpose. All fluids, except the urine passed during defecation, must be excluded. A small quantity of earth should be placed in the receptacle to begin with, and earth should be added after each defecation. If a large quantity of fæces is allowed to accumulate before the earth is thrown in, the mass is more liable to noxious decomposition in its interior. Besides, the odor from the uncovered fæces is in the meantime very offensive, especially as the contents of the closet are generally above ground, an excavation being unnecessary and indeed objectionable, unless the expense of a water-tight vault is incurred for the purpose of excluding surface and subsoil water and moisture. Hence it becomes almost a necessity to the success of the system in a mixed community, and especially where there are children, that some automatic method of applying the deodorizer be employed. A good closet of this kind is one on the principle of the Heap patent, such as is shown in elevation in Fig. 3453, and in section in Fig. 3454, by which the working of the closet may be understood. The lid is shown half open; just beneath it is seen the hopper (H), made of galvanized iron and hung upon the pivot X; attached to the upper posterior part of the hopper is a weight (I) which keeps it in the position indicated by the continuous lines when the closet is not in use. The seat (S) is hinged to the riser in front, and to its posterior edge is attached the small wheel or roller (W); when the seat is pressed upon, this wheel, acting upon the inclined plane of the hopper, forces it back to the position indicated by the dotted lines. When the pressure is removed the hopper flies forward, striking the buffer (R), and in this way a quantity of earth is thrown and scattered in the receptacle (P). The weight (I) assists in throwing the hopper forward. A "urine separator" may be attached for the purpose of keeping the contents of the pail as dry as possible. This attachment is not to be recommended: even though a disinfectant be placed in the urinal the latter may become offensive, and the separate vessel is unnecessary if a sufficient quantity of earth is used.

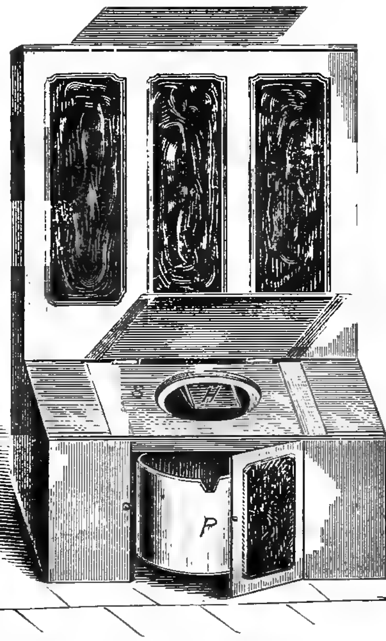

Fig. 3453.—Heap's Dry-earth Closet. Elevation.

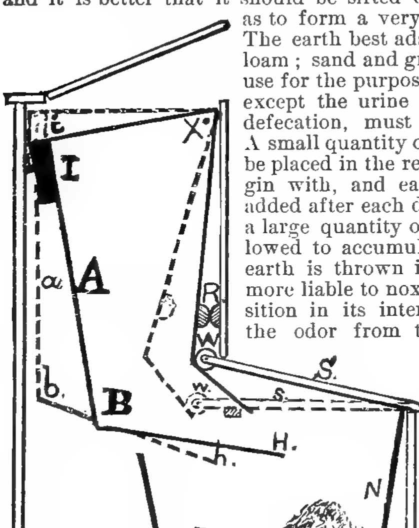

Fig. 3454.—Heap's Dry-earth Closet. Sectional view.

In the case of adults regularly employing a dry-earth closet, a simple contrivance will answer, such as that represented in Fig. 3455, which shows the excrement tub, B, beneath the seat, and the other tub, A, holding dry earth or ashes, which are applied by means of a scoop. The hinged door, C, permits the removal of the pails. It might for some reasons be preferable to do without this door, and to remove the pail through a hinged seat.

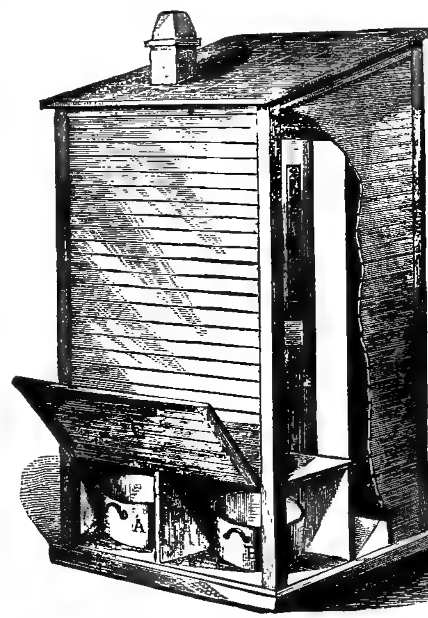

Fig. 3455.—Simple Form of Dry-earth or Dry-ash Privy.

Before leaving this subject, reference must be made to the closets invented by the Rev. Henry Moule, M.A., of Fordington, Dorset, England, to whom is due the credit of introducing the system of dry-earth closets, and who has experimented largely with them. The mixture of earth and excrement undergoes a species of dry fermentation, and should be kept dry till this takes place, a period of some six weeks being required; otherwise the contents of the closet must be removed to some place where they can be utilized without offence. If kept till the process of fermentation has taken place, the product may be used again and again with the same result. The amount of earth required is variously estimated, the average being about a litre, or one and a half imperial pint per head *per diem*. Most authorities consider that finely

sifted coal ashes answer almost as well as earth ; some think that they do not prevent the occurrence of offensive fermentation. In my own somewhat limited observation I have found them answer very well. Charcoal, made from burning street-sweepings and sea-weed, is said to be very useful, and to answer the purpose in smaller quantity than earth.

In some places so-called dry-earth closets have brought the system into disrepute by faults in the management: the earth not being dry and fine, its deodorizing and anti-putrefactive properties have been lost ; or the hopper becomes clogged ; or the receptacles are down below the ground-level and are not kept dry ; or slop-water is thrown in ; or there is neglect on the part of the corporation in providing dry earth and in seeing to the removal and storing of the product.

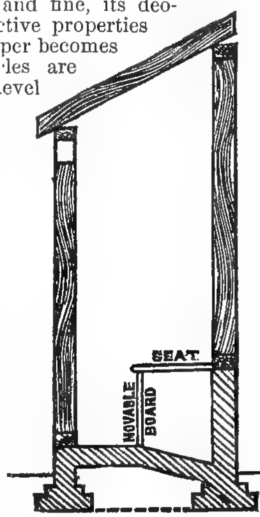

Fig. 3456.—Hull Ash-closet.

The invention of improved cinder-sifters has done much to render more easy the use of the dry-ash closet system, and it has also lessened the amount and improved the quality of the resultant products of the next system to which we have to refer.

(*b*) *The Midden System.*—Included under this system are several kinds of closets or vaults, which have taken different names, generally from the places in which they have been used. They differ somewhat in details, but have the following features in common : ashes, garbage, excrement, dust, waste-paper, and all household refuse, except slop-water, are thrown into a water-tight receptacle, from which the contents are removed at short intervals by scavengers. Fig. 3456 represents a section of the Hull ash-closet. The floor, back, and ends of the receptacle are of brick or masonry laid in cement. The refuse is thrown in through the hole in the seat. In front is a movable board, through which the contents may be removed by the scavenger's shovel and broom. A useful modification would be to hinge the seat at the left-hand end. I have recently been informed that this is often the case in Manchester. That city presents some of the transitional stages from the Midden to the "pail system." Fig. 3457 represents a mode by which the ashes are thrown into a movable receptacle as they are sifted, the cinders being kept for fuel.


Fig. 3457.—Manchester Cinder-sifter and Excrement-tub.

(*c*) *The Pail System.*—In this system pails or small tubs are placed beneath the seat ; and, as a rule, nothing but excrement is placed in the pails. Frequent removal takes place —in Rochdale once a week.

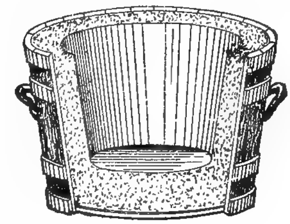
Fig. 3458.—Goux System : Pail lined with Absorbent.

A wagon, made airtight by rubber joints, takes away the full pails, fresh ones being left in their stead. The pails are provided with tight double lids. In some places they are strong, iron-bound wooden pails, or half-casks ; in others they are made of galvanized iron.

This system is principally in use in cities far removed from agricultural districts, and where the contents must be made into *poudrette* or artificial manure, and must, therefore, present a strong fertilizing power in small bulk.

In the Goux system, however, a slight departure is made, the pail (Fig. 3458) being lined with a slightly absorbent material, which, according to the trade circular of the Goux Company, may be composed of "stable litter, leaves, spent tan or hops, sawdust, shavings, shoddy, flax-dressings, or the thousand-and-one convenient substances to be found in every place." With the above a little charcoal, soot, gypsum, or other deodorant may be mixed. A little of this filling is placed in the bottom of the pail, the mould (Fig. 3459) is set upon it, and the interspace packed. It is stated that a boy can fill a hundred pails in an hour. When the pail is removed any filling projecting above the rest of the contents is broken down to cover the excrement.


Fig. 3459. — Goux System : Mould used in Lining-pail.

The Nottingham system differs still more widely, and resembles the Midden system, inasmuch as the ashes and other refuse are allowed to be thrown into the tubs. The reason assigned is that Nottingham is in an agricultural district, and bulky manure can be utilized. When the health officer has been notified of the existence of infectious disease in a house, a red tub is sent containing a germicide.

In all the above dry methods the closets require provision for ventilation.

(*d*) *Desiccation.*—I use this term to designate a method lately introduced, by which a continuous stream of air is made to pass over the fæcal contents of a trough or long vault beneath a series of closets. The method may be readily understood by a reference to the accompanying cut (Fig. 3460) of part of a section of a building ventilated by the process of the Smead-Dowd Company of Toronto. The foul air drawn off from the building is made to pass through the closet vault on its way to the foul-air chimney. The fæces are so dried that they may be handled without any danger of soiling the fingers. The system is in operation in several places in the States of Pennsylvania, Ohio, Iowa, Wisconsin, New York, and in the Province of Ontario, and it gives great satisfaction. The small heater seen at the base of the foul air chimney is for use on muggy, heavy days in summer, the furnace not being in operation. Ventilation of the closets is efficiently secured, the air being drawn through the seats.

It should be noted that in all the dry methods separate provision must be made for disposing of the bedroom, kitchen, and laundry slops.

3. The Water-carriage System.—This has already been considered, so far as it relates to the interior of houses, under the headings Habitations, General Principles of House Plumbing, and will be further treated of in the article Sewerage, the ultimate disposal only of the contents of sewers being taken up in this article.

4. Pneumatic Systems.—Under this heading are to be included (*a*) the Liernur system and (*b*) the Berlier system. The Shone system is sometimes called a pneumatic system, but it is really a mode of pumping, in connection with the water-carriage system, and will be referred to in the article Sewerage.

(*a*) *The Liernur system* is the invention of Captain Liernur, a Belgian engineer. A large steam air-pump exhausts the air in a set of central reservoirs, and in the air-tight iron mains which connect these central reservoirs with smaller ones under the sidewalk crossings in the streets (Fig. 3462). These latter are visited daily. By means of a key a valve is opened in the pipe leading from the street reservoir to the central reservoir, and the air in the former being thus partially exhausted, the valve is closed, and another valve, in the pipe leading (by its branches) to the houses, is opened. This operation having been repeated several times, the sewage matter contained in the drains and in the traps at the bottoms of the soil-pipes is drawn into the street reservoir, and thence to one of the central reservoirs. From these latter it is raised, also by a vacuum process, into tanks "hermetically sealed." From these it may be drawn into air-tight barrels and taken to the country for direct application to the land, or converted into *poudrette* or artificial manure. The main pipe connects with the street reservoir by two branches, one at the top of the reservoir, by which the air is exhausted, the other reaching nearly to the bottom, by which the sewage is drawn out. Some of the closets are supplied with a mechanism by which a small quantity of water is supplied at each using; but most of them have no water-supply, the hoppers being so constructed that no droppings are supposed to touch their sides in falling to the trap; these closet-traps are never emptied, the main soil-pipe being open at its upper extremity. It will be evident that it would be impossible to draw the contents of the pipes out by suction, unless the whole bore of the pipe were filled at certain points. This is done at intervals by making an upward grade, through which the sewage is drawn, and then it runs down to the next rise. The effect is similar to that of suction on a siphon-trap, or series of siphon-traps.

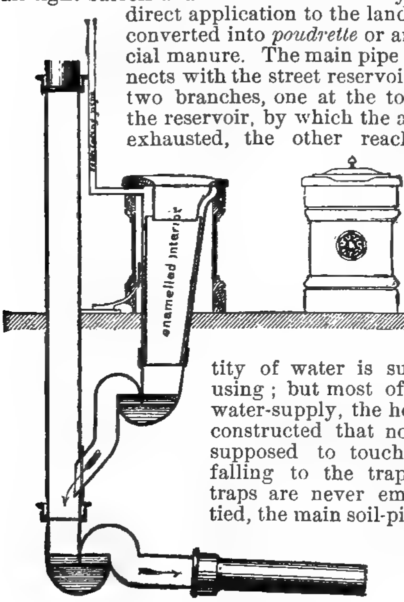

Fig. 3461.—Liernur Pneumatic System: Closet, Soil-pipe, and Commencement of Drain.

(*b*) *The Berlier system* receives its name from its originator, M. J. B. Berlier, and is employed in Paris.

In it there are no street reservoirs, their place being

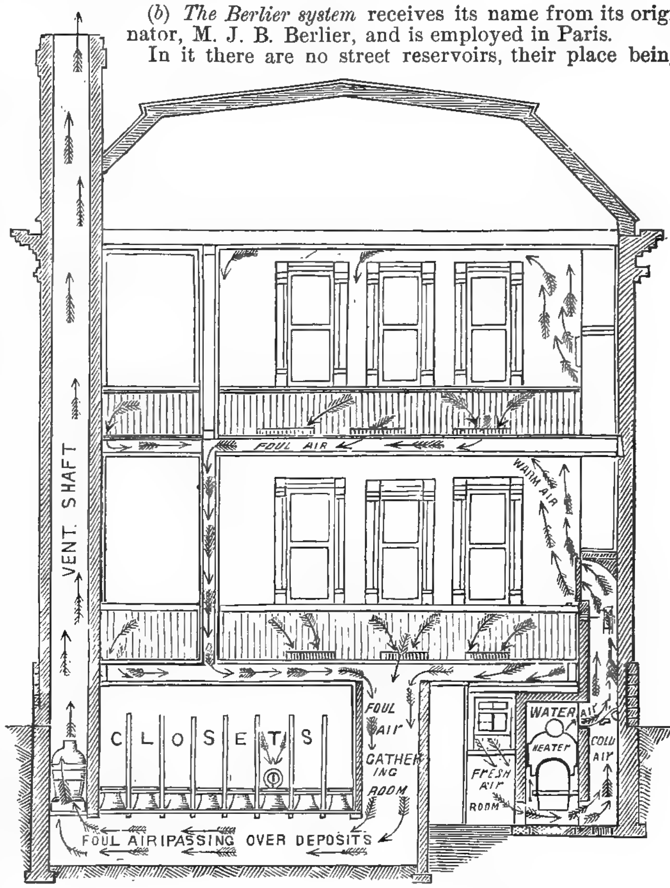

Fig. 3460.—Smead-Dowd System of Closets.

taken by a tank and evacuator in each building. The emptying of the latter is automatic. The soil-pipe empties its contents through the top of the tank (Fig. 3463), which contains a strainer for intercepting cloths and other large articles which might obstruct the pipes. The presence of these may be detected by means of an axle, on which are fixed arms, or "beaters," and which can be revolved from the outside. These beaters also serve to break up masses of fæcal matter lodged on the strainer. Obstructions may be removed through a door in the tank. From the tank the sewage passes into the evacuator. The bottom of the latter is conical, and communicates with the pneumatic tube, the opening between the two being closed by a rubber ball when the evacuator is empty. This ball is attached to a large, pear-shaped float, which rises when the fluid in the evacuator reaches a certain height. When the float and ball rise, the fluid rushes from the evacuator into the pneumatic tube. The float works up and down on a vertical rod, and so, as the fluid rushes out, the ball again falls into its place. There is now no further obstruction till the sewage reaches the central reservoir, or vat, in which the pneu-

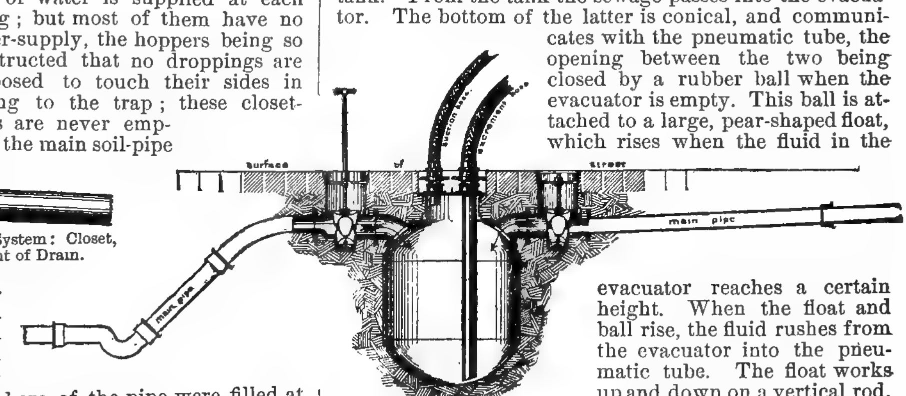

Fig. 3462.—Liernur Pneumatic System: Street Reservoir and Pipes leading to and from it.

matic system terminates. The pneumatic pipes from the houses and in the contiguous streets are ten centimetres (four inches), and the main pipe is fifteen centimetres (six inches) in diameter. From the vat the sewage is forced, by a rotary pump, into the river for the present; but eventually it is intended to utilize it in some adjoining country district. It will have been seen that the pneumatic action in this system is constant, and the emptying of the house-receivers automatic, the only dependence upon corporation servants being at the central pumping-station.

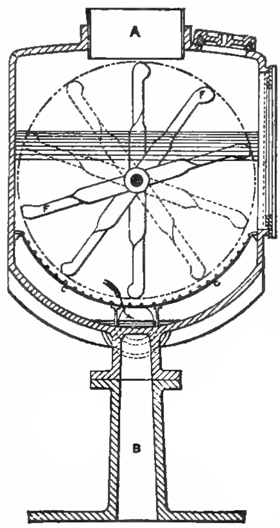

FIG. 3463.—Berlier Pneumatic System: "Receiver." A. Entrance of soil-pipe; B, stand; C. strainer; F, arms revolving on axle (E); the arrow shows pipe for passage of sewage to the "evacuator."

It may here be noted that these pneumatic methods, like the dry systems, do not provide for the disposal of domestic, kitchen, and bedroom slops, the object being to obtain the excrement in concentrated form for utilization. Further reference to their disadvantages and to any reasons which may be advanced for their existence, will be made when we come to compare the relative merits of the various systems, after considering the modes of ultimate disposal.

II. ULTIMATE DISPOSAL.—At the outset it may be stated that, as a rule, no system of sewage disposal will yield a pecuniary profit, although in a few exceptional cases such a result is claimed—as, for example, at Pullman, Ill., and in some places on the continent of Europe. The plains of Gennevilliers, on the outskirts of Paris, have, by the employment of sewage, been transformed from sandy wastes into beautiful gardens, and the value of property has been greatly enhanced. But, as a rule, the highest result that is looked for is to gain as much as will reduce to a minimum the cost of ridding a community of its waste products, which, if not properly disposed of, would produce an increase of sickness and mortality.

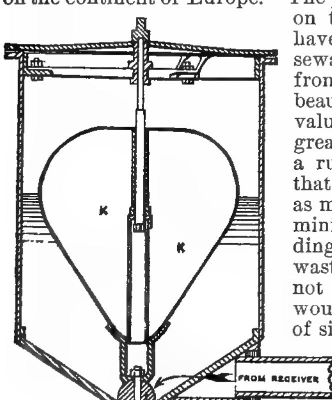

FIG. 3464.—Berlier System: "Evacuator." K is a pear-shaped float, which on rising carries the ball I, and allows the sewage to rush through the discharge-pipe J, into the pneumatic tube below; the arrow indicates the other end of the pipe shown by an arrow in Fig. 3463.

In the case of manufactories it sometimes happens that neglected waste products may be converted from offensive nuisances into substances of commercial value.

In order to simplify and condense our consideration of ultimate disposal, we may classify refuse products as follows:

1. Concentrated excreta, or night-soil, which has not undergone any artificial change, and which has resulted from the adoption of the privy-pit, privy-vault, pail, or pneumatic systems.
2. Garbage.
3. Dry-earth and dry-ash products.
4. Liquid sewage.

1. THE MODES OF DISPOSING OF NIGHT-SOIL are (*a*) direct application to land; (*b*) manufacturing into artificial manure; (*c*) cremation; (*d*) carbonization.

(*a*) *Night-soil is sometimes applied directly to the land.* This cannot be done without producing an offensive nuisance to persons residing in the neighborhood, and it is difficult to find an uninhabited place near enough to the community from which the night-soil is removed. "Sanitary agents"—this is one of the recent euphemisms—will frequently annoy a rural neighborhood till the nuisance and the deterioration of health are no longer tolerable, and the arm of the law is invoked with sufficient pertinacity to put a stop to their proceedings.

On the outskirts of large cities where there are extensive market-gardens, cesspools are sometimes built, the night-soil is mixed with fluid and applied to the soil in which are growing plants. Sufficient care is not always exercised in the mode of application, and, in case the plants are ready for market, this may give rise to unpleasant and baneful results.

(*b*) *The manufacture of dry artificial manure.* This may be effected by drying the excreta and resolving them into a powder, as, for example, in Amsterdam, where the Liernur system is employed, and *poudrette* is manufactured by the aid of superheated steam and special machinery. Or the excrement may be mixed with other substances before drying, as in Rochdale, where the pails are emptied into trenches containing ashes, the drying being hastened by the addition of sulphuric acid; or in Birmingham, where one of General H. Y. D. Scott's processes is employed, namely, adding to the contents of the pails magnesia, distilling off ammonia, collecting it in sulphuric acid—forming a sulphate of ammonia—and then adding phosphoric acid. The solid residue is dried for manure. Heat from the burning of other refuse is employed in this process.

In Glasgow admixture of ashes and street sweepings takes place; the process will be described presently. Poudrette made from excreta alone cannot be stored with full confidence that it will remain innocuous. Fevers have been known to result from its storage and transportation, and these have sometimes presented typhoid characteristics.

(*c*) *Cremation* is another mode of disposing of night-soil. It is in operation in many places on this continent as well as in Europe, and among those where I have been informed by health authorities that it has given satisfaction, I may mention Montreal, Ont., and Des Moines, Ia. A description of these cremators or destructors will be more appropriately given presently, when we speak of the associated destruction of garbage.

The dried excreta resulting from the use of the Smead-Dowd system may be readily burned on the spot. Iron caps are provided for the closet-seats, with a shallow rim coming down past the wooden seat. The whole thus becomes an iron vault, and a small fire being kindled at one end, the contents of the vault are quickly burned out. Or they may be raked out and thrown into the heating furnace. They may, of course, be carted away without offence and used on land.

(*d*) *Carbonization* is the term employed to designate a process with which the names of Mr. Hickey, of Bengal, Mr. Stanford, and, later, Mr. Fryer, of Manchester and Nottingham, have been connected. Fryer's patent method has been used in Manchester. The dry refuse being taken to the works along with the pails, the contents of the dust- and garbage-carts are sorted in a manner similar to that employed in the more recent works at Glasgow presently to be described. The coarser portions are burned in the destructors, while all suitable material is, by the heat from the destructors, reduced to charcoal in revolving cylinders, called carbonizers; and in a third set of chambers, called concretors, the excreta, mixed with a little sulphuric acid, are resolved into artificial manure, a small quantity of carbon from the carbonizers being sometimes added.

2. GARBAGE.—As a typical example, conveying much useful information regarding some of the recent modes of disposal of refuse, I propose to describe the system adopted at the works lately set in operation at Crawford

Street, Glasgow. I may premise by saying that in Glasgow they are by degrees abolishing the pit and vault of former days, that the number of water-closets is increasing, and that in addition the pail system is in use. The works at Crawford Street present some improvements on similar works established a few years ago in the same city.

I quote from the remarks of Lord Provost McOnie at the opening of the works: "All the carts on entering are weighed. Any material, such as stable manure, which requires no manipulation, is carted straight into the middle floor, where closed hatches are provided for simply shooting it into the railway wagons. All the general city refuse, which is composed of (1) contents of ash-pits and bins, (2) excreta, and (3) street sweepings, is taken to the top floor, where special provision is made for each variety. The contents of ash-pits and bins are shot into revolving screens of new design. Each screen (making fourteen revolutions per minute) has a double action, and, although in one piece, is practically a screen within a screen. By the first action upon the inner mesh, sloping from west to east, all the rougher rubbish which will not pass through a one and one-third inch opening is separated and delivered on a travelling carrier at the east end of the screen; and by the second action upon the outer mesh, sloping in the opposite direction, the material which has passed through the inner mesh travels back over the one-half inch outer mesh. The material—chiefly cinder—which passes over this one-half inch mesh is delivered at the opposite end of the screen from the rubbish, and is thereafter passed down a shoot to the front of the boilers, where it is used as fuel and serves to raise steam for the works. The fine ash and smaller manurial particles fall through both meshes of the screen, and thence down a shoot into the mixing machines, which stand upon an elevated platform, on the floor immediately below. Into these mixers there passes at the same time a mechanically regulated quantity of excreta. The carts and vans in which this material is collected also ascend to the top floor, where the contents are passed through gratings into closed cast-iron tanks, which rest on the second floor, and from which, by a simple mechanical arrangement, the desired supply is allowed to escape into the mixers along with the fine ash, which absorbs and deodorizes it. In order to fix the ammonia and further deodorize the compound, provision is made for adding sulphuric acid, or other disinfectant or deodorant, to the excreta in the tanks." The other material which is shot into the mixer is the more concentrated detritus from the paved streets of the city (the sweepings and scrapings of the macadamized streets being sent off to a heather swamp which is being reclaimed). It is also taken to the top floor, passed, if wet, through drainage tanks, and then added, in certain proportion, to the compound already described in "the mixing machines, whose revolving blades thoroughly mix the whole into a deodorized compound, which is delivered into the railway wagons direct, and the farmers are supplied with a prepared manure in good condition for spreading on the land. The rough rubbish, it has been observed, is delivered by the inner screen on a travelling carrier. This is an endless web of iron plates on pitched chains, which is made to travel thirty feet per minute. Women are stationed in front of it to pick off anything which can be sold or utilized. One picks off, first of all, what is manurial, such as dirty straw, pulsy matter, vegetable refuse, etc., and this garbage she drops down a shoot by her side to the wagon direct, where it gets mixed with the compound as it comes from the mixer. The other materials picked off for use are old iron, old boots, meat tins, rags, paper, etc. The remainder is shot from the carrier into a specially constructed cremating furnace, where it is reduced to cinders, which are, of course, innocuous, and, like common furnace ashes, go to make roads or fill up ground. [In some places they are ground up for mortar and sold.] The various articles of garbage above referred to are mostly sold to persons who can make use of them. Old iron goes for precipitating copper; ammonia is extracted from old boots; solder is taken from meat tins, and so on." There are four sets of rails running inside the building, with a trav-

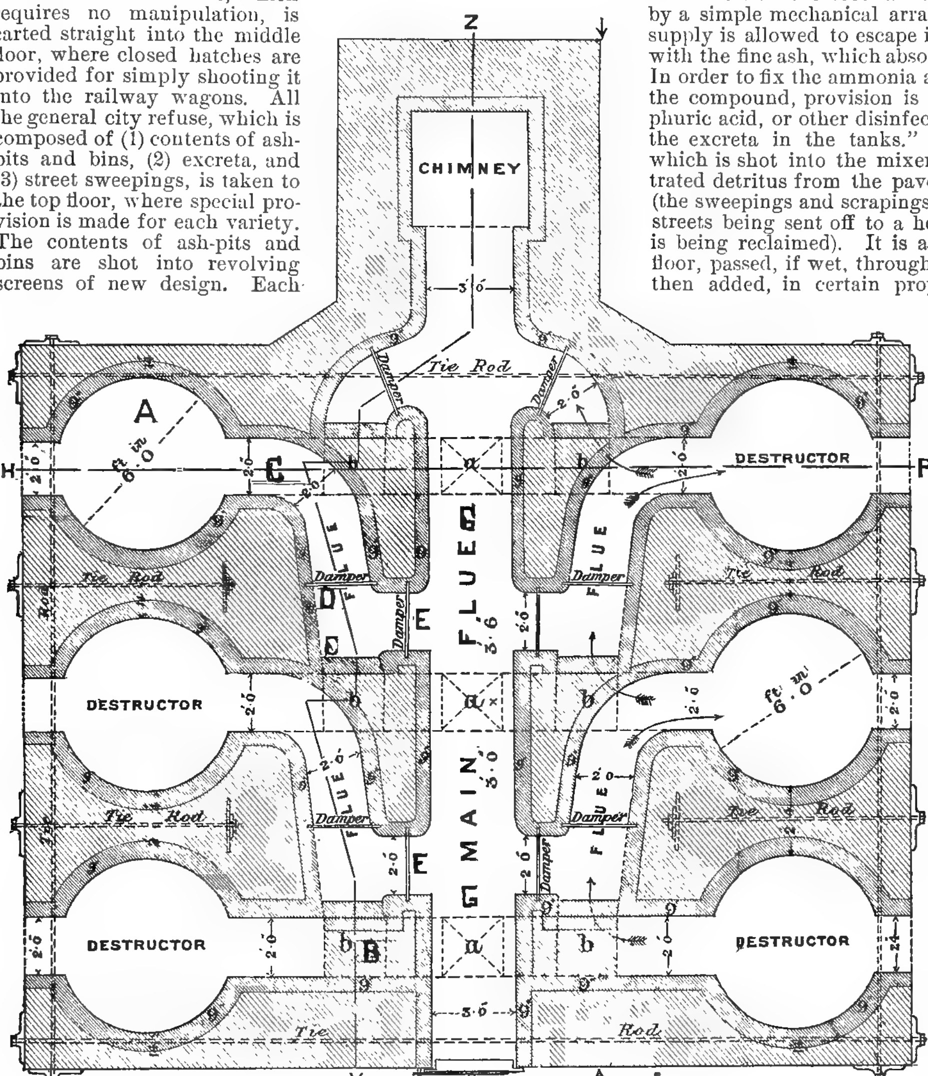

Fig. 3465.—Beehive Destructor: Plan through Line S T of Fig. 3466.

erser for shifting wagons from one to the other; all traversing and hauling are done by steam-power. A large exhaust-fan carries off foul air and sends it through the furnace-fires. Lavatories, baths, and eating-rooms are provided for the work-people. One great feature of this establishment is that nothing capable of decomposition is left on the premises for twenty-four hours.

Of refuse crematories, or destructors (as they are mostly called to distinguish them from *incineraria*), there are already many varieties. In the most successful it is claimed that little or no fuel is used, except to start the fires, but that, on the other hand, the heat from the burning refuse is used in destroying night-soil, furnishing motor power, ventilating sewers, etc. One that has been long and extensively used is the Bee-hive Destructor of Mr. J. E. Stafford, A.M.I.C.E., of Burnley, Lancashire, England, for which there are agents in America. There may be used either a single cell-destructor, or one of many cells, the latter being the most effective, the heated gases from one cell being carried over to the next—contributing heat and giving up to destruction the noxious vapors. A destructor with six cells is shown in Fig. 3465, the plan being taken just below the grates, on the line *S T* of Fig. 3466. Fig. 3466 shows a vertical section through two opposite cells on the line *H P* of Fig. 3465. Fig. 3467 is a vertical section through the zigzag line *Y Z* of Fig. 3465, and shows the flues leading from the upper surface of one fire to the lower surface of the next, and from the last fire to the chimney.

Fires being lighted on the grate-bars *K*, carts are driven to the shoot *J* (Fig. 3466), down which the garbage is dumped; sliding down the refuse chamber *B*, where it becomes somewhat dried, it reaches the combustion-chamber *A*. When the fires are first started, or when from any other cause there is a poor draught through the flues *C, C* (Figs. 3465 and 3467), the dampers *D, D, D* (Figs. 3467 and 3465) may be shut, and *E, E, E* opened (Fig. 3465), and the smoke will pass through the flues *b, b, b,* directly to the main flue *G*, and so to the chimney. When the fires are good and the flues *C, C* clear, the position of the dampers is reversed, and the vapors pass through the flues *C, C* and through the successive fires on their way to the main flue *G*. As in all crematories, the parts exposed to fire are lined with fire-brick.

The Engle Cremator "has been recently invented at Des Moines, Ia.; it contains two fireplaces, one at each end, and is so arranged that the gases of either can be passed through the other fire by a shifting of dampers. The bottom of the furnace is made of heavy iron plates, so set that they form a chamber beneath, through which the fire may pass on its way to the flue. Just above these plates

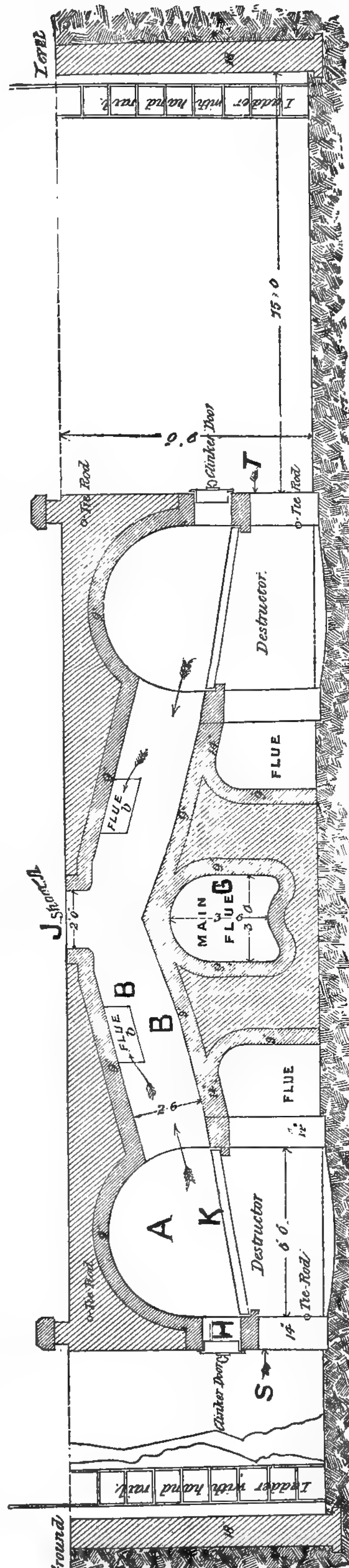

FIG. 3466.—Bee-hive Destructor: Section through Line *H P* of Fig. 3465.

there is a grating upon which the material lodges after it is dumped or thrown in at the top. The fires are so arranged that one will pass over the top of the material to be consumed, driving the gas forward and downward through the other fire, there inflaming all of the gases from the material, and using the heat to maintain the fires of the furnace, and at the same time rendering the escaping material [gas] from the flues inodorous and nearly transparent."

At Montreal, Q., garbage and night-soil are cremated in a furnace (Fig. 3468) of very simple construction, and the result is said to be very satisfactory. The furnace was planned by the City Contractor, Mr. William Mann. The grate is a little over sixteen feet long and nine wide, extending by a gentle upward incline from the fireplace at one end, where the fire is started, to the flue at the other end. The combustion-chamber is quadrilateral, a little over sixteen feet long, nine broad, and ten high. On each side of it are nine doors; three at its upper portion open out upon a stage on to which carts are driven, the refuse being put into the furnace through these doors; the next lower doors open just above the line of the grate, and are used for stirring the fire; the three lowest are at the bottom of the furnace, and are used for removing the ashes. Under the grate is a receptacle for water (not shown in the sectional cut, Fig. 3468). This may be varied in different furnaces, the object being to prevent over-heating and destruction of the grate. This latter consists of iron bars, their ends being laid on the brick, the inter-spaces between them being two inches. The flue is about twenty two inches long and eighteen wide—inside measurement. The chimney is ninety feet high. Among other furnaces may be mentioned the Rider Furnace, of Pittsburg, Pa., which has been but a very short time in operation, and of which, therefore, nothing very satisfactory can be said.

While there is no doubt as to the success of garbage-cremation, the various forms of furnace may be said to be still on trial, as the reader may have inferred from the above descriptions. It seems as though the best results would be obtained by cremating on a large scale, and maintaining a constant high temperature; by so arranging the furnaces that surface-heat may be utilized in drying material on its way to the fire; and by consuming the heated gases on their way to the chimney.

Individual householders can materially aid in the disposal of garbage. Vegetable matters, if carefully kept from grease and animal contamination, may be given to a horse or cow, if one is kept. In some cities and towns garbage is, to a great extent, burned by the householders. It may be prepared for burning in a receptacle fashioned something like a steamer used for cooking.

3. OF DRY-EARTH AND DRY-ASH METHODS nothing need be added to what was said in the section treating of immediate disposal.

4. LIQUID SEWAGE.—The modes of ultimate disposal are: (*a*) Emptying into tanks or cesspools; (*b*) discharging into some body of water; (*c*) irrigation; (*d*) filtration; (*e*) precipitation and deodorization.

(*a*) *Cesspools* are excavations in the earth into which sewage is allowed to flow. They are sometimes water-tight, and sometimes the sewage is allowed to percolate through the bottom. Their walls and roofs may be of wood, brick, masonry, or cement. Sometimes the walls are allowed to be pervious as well as the bottom. They are generally provided with an overflow, unless the soaking away of the sewage is fully insured. Old wells are occasionally turned into receptacles for sewage. In those rare cases where cesspools are allowable, they should be ventilated by a tall outlet, and shorter inlet, shaft.

(*b*) *Discharge into some body of water.*—This is the mode which has been generally adopted and continued in each individual case, until it has caused a nuisance such that means have been taken to prevent it. So general had the nuisance become in England, owing to the density of population, that in 1876 the Rivers Pollution Prevention Act was passed, providing that no rivers or streams should be polluted through the admission of crude sewage. For years, both before and since that time, the question of sewage-disposal has engaged the attention of numerous parliamentary committees and commissions, and of many of the foremost scientific men. Some places, as, for example, cities situated on rivers like the Lower Mississippi and St. Lawrence, are so favorably situated that they are relieved from this difficulty; but in very many places on this continent it has become a very urgent and serious one, owing to the pollution of the atmosphere and of the sources of water-supplies; and it has given rise to commissions of inquiry, the reports of some of which form valuable contributions to the literature of the subject. Among them may be mentioned the reports of Dr. Charles F. Folsom, Mr. J. P. Kirkwood, C.E., and others, in the Annual Report for 1876 of the Massachusetts State Board of Health, and the later report (1884) of Mr. Samuel Gray, City Engineer of Providence, R. I.

In discharging into the ocean much difficulty has arisen from the action of tides, coupled with the fact that oxidation takes place far less readily than in fresh water (see Sewerage).

(*c*) *Irrigation.*—This consists in discharging the sewage upon or into the soil in such a way that it shall be acted on by growing vegetation. The soil acts as a filter, straining out particles; then, by the separating action of the earth-particles, a large surface of the fluid is exposed to the action of the air, and the organic is reduced to inorganic matter. The experiments of Müntz, Pasteur, and others, go to prove that this process is aided by micro-organisms in the soil. Vegetation also assists by utilizing the inorganic substances.

Hence, it will be apparent that there must be alternations of sewage and air in the soil, and that the soil must be in such a condition as to allow the sewage to run through and out of it, and that the vegetation must not be overdosed. There are great differences, moreover, in the capacity of various kinds of plants for utilizing sewage: In England osiers, Hungarian grass, Italian rye-grass, cabbages, mangolds, and other coarse-grained and succulent vegetables are especially recommended. But the market must also be considered. During a recent visit to Pullman the writer was informed by the courteous farm-superintendent, Mr. E. T. Martin, that he grew Italian rye-grass, but could not get cattle-feeders to take it away, although he offered finally to give it to them. The stalks grew very thick, rank, and watery. The principal crops at Pullman are cabbages, celery, and onions; turnips do well, but the market is unreliable. Potatoes fail utterly. Other vegetables can be raised, but those mentioned are found to suit best. It is a common mistake to suppose that rain is not needed on sewage-farms; it is necessary for the destruction of insect-pests. The Pullman farm has yielded a fair profit on the investment, apart altogether from sanitary advantages, except in those years

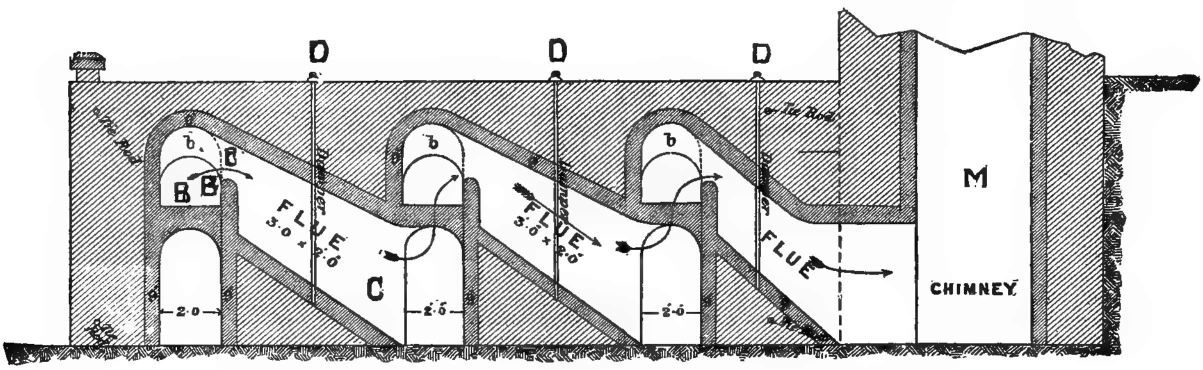

FIG. 3467.—Bee-hive Destructor: Section through the Zig-zag Line *Y Z* of Fig. 3465.

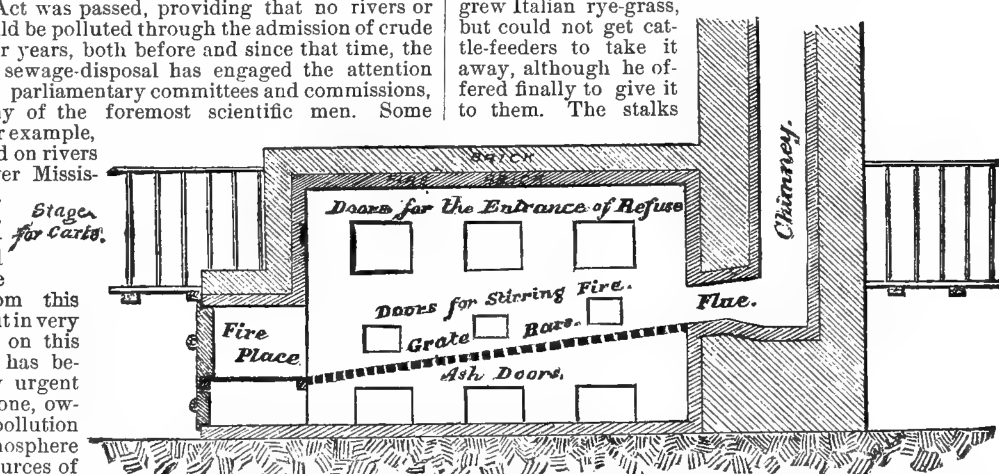

FIG. 3468.—Cut showing principle of Montreal Garbage Destructor.

when frost or other unfortunate accidents have had a destructive influence.

Sandy loams, and loams with a substratum of gravel or chalk, are well adapted for irrigation. In the case of stiffer soils, subsoil drainage is necessary. Experience has shown that it is not well to use pipes of a smaller diameter than four inches for this purpose. They should be laid at a depth of from four to six feet, but the distance between the lines of drain varies very much in practice; in some places we read of their being forty inches apart, in others as much as eighteen feet. These subsoil pipes should, of course, be porous and open-jointed.

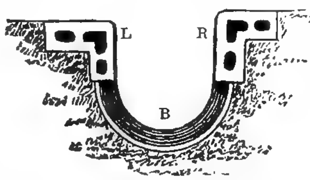

FIG. 3469.—Tile-carrier, with separate Side-pieces.

Solid substances are screened out before the sewage is applied to the land. In some places the sewage is conducted or pumped to the highest part of the farm, and thence distributed by sluices and "carriers" in the several methods presently to be described; in others it is carried in underground pipes and pumped from hydrants placed at intervals—one hydrant to every two and one-third acres is the apportionment at Pullman. It is applied to the land in various ways: it may be poured out upon it in a stream, the direction of which may be changed by hose, boxes, or half-pipes, which latter may be turned with the foot; to this the term "broad irrigation" is applied. Grass land often receives a "surface treatment" of this kind, a section thus treated being fenced off for a few days before cattle are allowed on it. A rain following the application of the sewage improves the land very much for pasture purposes. A modified form of broad irrigation is what is termed the "contour" or "catch-water" method, which consists of a series of shallow channels, or carriers, terraced one above the other, with gently sloping land between; the water flows into and overflows the highest carrier, then down the slope into the next, and so on. The carriers follow as far as possible the contour of the ground, and the distance is regulated by the slope and nature of the soil—an average of two hundred feet is recommended.

The "carriers" may be formed in the earth itself, which is generally firm enough, or they may be edged with turf, or tiles may be used, as shown in Fig. 3469. The capping of these tiles may be used as a footpath—a great advantage. It may be noticed, too, that the side R is higher than L, which allows the sewage to overflow. In carriers valves are sometimes placed, similar to the flap-valve in the Palmer trap (see Sewerage), but regulated as to the amount of opening by a handle. These must, of course, be contained in a closed-pipe carrier. The side-pieces (L, R, Fig. 3469) are made separate from the bottom tile B, and additional side-pieces may be let in, thus making the carrier deeper, if required as a conducting main. These main carriers or sluices are sometimes constructed in the earth and edged as above described, or they may be of tile or cement.

Fig. 3470 represents a farm on the "flat-bed" system. The surface must be graded so as to have a slight inclination—say one foot in fifty, to one in one hundred and fifty, according to the nature of the soil, the crop, and the amount of irrigation required. The sewage is conducted along the main sluice A, E, and can be stopped at any desired point by the main dam F; it is led into the laterals by the gates G, G, G, and it may be stopped at any required distance by the lesser dams D, D. The sewage is thus made to flow over a portion of the land for a few hours at a time, at intervals of as many days as may be found necessary. A method is in operation (and is being gradually extended) at Pullman by which a more uniform result is obtained. The beds are arranged in sets of six, three on each side of a broad, low, turf

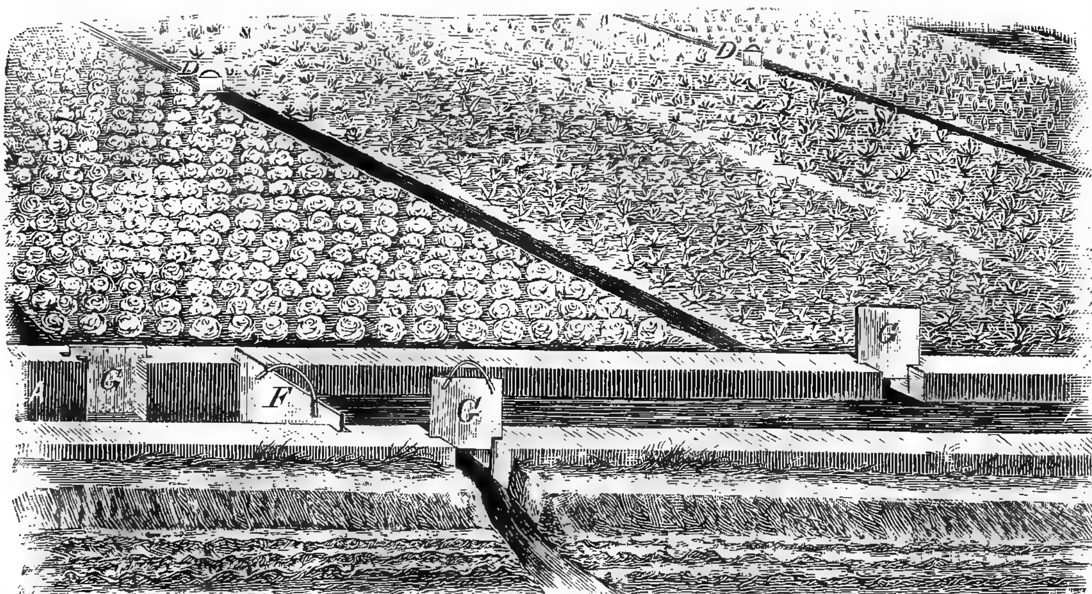

FIG. 3470.—A Sewage-Farm, Irrigated on the Flat-bed System. (From Dr. Folsom's Report.)

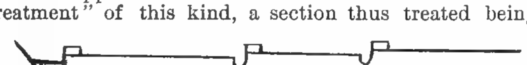
FIG. 3471.—Section of Land Irrigated on the Flat-bed * System, the sewage in this case being confined by a strip of turf on the lower edge of each bed, and supplied by a carrier at the upper edge.

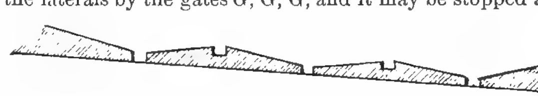
FIG. 3472.—"Pane-and-gutter" or "Ridge-and-furrow" System of Sewage Irrigation.

* I am aware that the term "flat-bed" system has received a different application at the hands of some; but it is used as given in the text by Mr. Wm. Eassie, C.E., F.L.S., F.G.S., as also are the terms "pane and gutter" and "sewage-cropping," respectively applied to the next two modes. See Our Homes, Cassell & Co., London, 1883.

wall, which runs lengthwise down the slope; the remaining sides of each bed are also surrounded by a little turf wall, and in this rink-like form the sewage can be more evenly spread; a hydrant stands at the head of the broad dividing wall, and, by means of a sluice-box, supplies sewage to the beds on either side; at the lower end of each of the first and second beds, close by this median

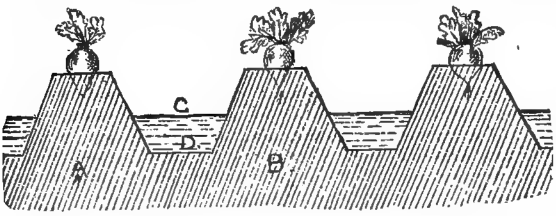

FIG. 3473.—"Sewage-cropping," by allowing the sewage (C) to flow in the gutter (D) and percolate into the beds on either side.

wall, is a small sluice-gate, so that the sewage can be let into the lower beds only, or into any of them at will.

In Fig. 3471 is shown a section of a series of beds on a somewhat similar principle.

The "pane and gutter" or "ridge and furrow" method is represented in Fig. 3472.

The land should be deeply cultivated and well pulverized, and arranged in ridges and furrows so as to form long beds, as shown in Fig. 3472. These should be from forty to ninety feet wide, according as the land is light and loamy, or of a less porous nature. The slope should be from one in twenty to one in forty, according to the nature of the soil. The sewage is then conducted in a carrier or shallow trench along the ridge, and allowed to overflow and soak through the sloping bed; if grading and distancing be carefully done, there will be little overflow left to be carried off in the gutters by the time they are reached.

In some places porous or perforated and open-jointed tiles are placed on the ridges instead of the carriers.

Another mode of applying the sewage is to allow it to flow into gutters or channels in the earth, and soak through the sides of these channels into beds on either side, from

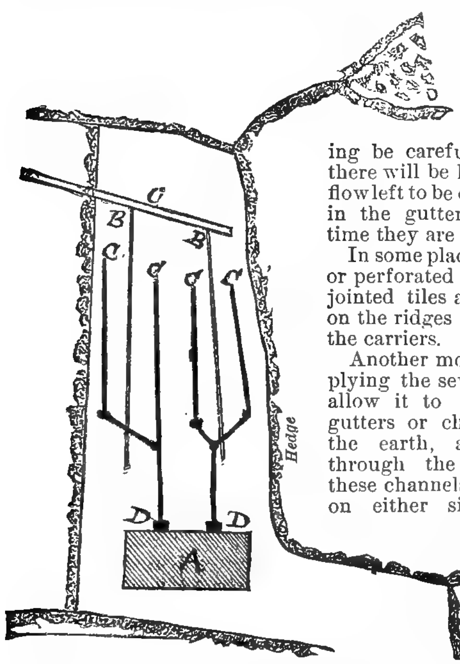

FIG. 3474.—A Diagram showing the mode of disposing of the Sewage of the Double Cottage A, by Subsoil Irrigation.

which it is taken up by the roots of vegetation. It will be evident that the sides of these channels will require to be scraped or loosened more frequently than in the other methods, so as to allow more ready percolation. Fig. 3473 gives an example of this method of irrigation, to which the term "sewage-cropping" is applied by Mr. Eassie. In this case the distance A B from centre to centre of the beds is about two feet, but they are often much wider; the depth of sewage-space in the gutter, C to D, is about nine inches; the length of the distance to be traversed in the gutter by an outflow of sewage will, as before, depend upon the character of the land, and may be about one hundred feet in light soils, and more in less porous soils.

Subsoil Irrigation.—There are at times circumstances, such as close proximity to dwellings, which render it undesirable to have sewage exposed on the surface, and in these cases it may be applied about a foot below the surface. This must not be confounded with subsoil drainage referred to above. Unless the subsoil is very porous, we still have to employ subsoil effluent drains below the subsoil irrigation-drains. This is shown in connection with the disposal of the sewage of two cottages in Fig. 3474. It is not prudent to have the sewage discharge into the soil near the dwellings, and the black lines nearest the tanks D D represent water-tight glazed tiles which conduct the sewage into porous tiles with open joints, represented by the branch lines C C C C; the effluent drains are represented by the light lines B B, converging into O, the main effluent. Subirrigation-drains have to be raised, as they are liable to become clogged. It is well to do this every season, or bends only may be raised, as they are most liable to clog. In taking up the drains another advantage may be gained, as their lines may then be laid in fresh portions of the soil.

In places where the flow is small, as in private houses, the sewage, if left to discharge as formed, would not reach the end of the system of pipes, but would expend itself near the point of delivery. To overcome this difficulty a tank is employed, the sewage being discharged periodically. The tank may be made to discharge by some automatic arrangement, as seen in Field's Flush-tank (Fig. 3475). This is a cylindrical iron tank, *A*. In the case of its receiving sewage from a disconnected pipe (see Sewerage) it should have a trapped inlet, *B*, which also serves as a movable cover. *C* is a ventilating opening; *D* is the siphon; *F*, termed the "discharging trough," consists of a small chamber, which may be turned around so that it may connect properly with the pipes *G*, through which the sewage discharges. It has a movable cover for getting at the mouth of the siphon. This trough forms a temporary check to the flow, so that the siphon can be brought into action. Another advantage of this periodic discharge is the period of rest which is given to the soil, the necessity for which has been alluded to.

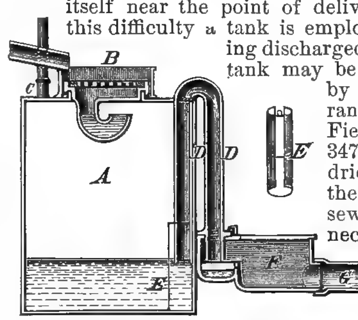

FIG. 3475.—Field's Automatic Flush-tank.

In irrigation on the large scale this intermittent action must be regulated by the attendants according to the crop. Sometimes it is desirable to allow three or four days to elapse between the successive irrigations. It is always desirable to have a fallow or idle field on to which sewage may be turned, when the crops would be injured by it, or when they are being taken off.

In irrigating on the large scale the distance traversed is generally sufficient to break up fæcal matter, and the action of pumps has a similar effect, so that all may be turned on to the land. There are many other matters in sewers, however, which must be screened out. Where their value as manure is not a consideration, the excreta are sometimes intercepted, and treated by some of the methods recommended for night-soil. In household irrigation—by gravity—they are generally intercepted. The solids are sometimes precipitated by some of the methods presently to be described, and the supernatant fluid alone is used in irrigation. This is not to be recommended from an economic point of view.

I have before stated that in the dry and pneumatic methods the disposal of the slop-water has to be provided for. This may be done by means of irrigation.

Town sewage can be far more profitably treated if the separate system of sewerage (see Sewerage) has been adopted, thereby rendering the sewage less in quantity and more concentrated.

The amount of land required for irrigation will, of course, vary with the nature of the soil and character of the sewage, but one acre to one hundred people is given as a fair proportion.

It was at one time considered doubtful whether sewage could be disposed of by irrigation in winter in very cold climates. This difficulty has been solved by the experience of Dantzig, of the City of Pullman, before alluded to, and of the State Asylum for the Insane at Augusta, Me., where the sewage flows out in winter. Its warmth keeps it from freezing, and it flows over the ground; if this is covered with snow it works its way underneath. It is found that the soil purifies it even without the action of growing plants.

(*d*) *Filtration.*—Intermittent downward filtration resembles very much the mode of irrigation with subsoil drainage. The drains are placed at a greater depth if the nature of the soil and outfall permit, and larger quantities of sewage are poured upon the land, and with greater frequency; as less regard is had to the paying result in cropping, a less quantity of land is required. The land is divided into several filter-beds—four at Merthyr Tydvil—the sewage being successively poured for a certain number of hours upon each; in this way time for aëration is given. At Merthyr Tydvil irrigation upon another tract has been added.

Upward filtration has been tried, as at Ealing, but has not proved satisfactory. Of carbon-filtration the same may be said, the carbon being at present too expensive.

(*e*) *Precipitation and Deodorization.*—After the agitation against sewage-pollution began, a vast number of processes were proposed, ranging from simple subsidence in tanks to the use of chemicals, appalling in their number and variety. It most cases these chemicals are mixed with the sewage in settling tanks, the clarified liquid being decanted off and the precipitated sludge being dried, or put on land at once. Some of the processes contemplate the addition of the chemicals in the sewers. Among the most recent of these is the permanganate of soda process of the Widnes Alkali Co., of Widnes, Lancashire, which may be understood by the accompanying cut (Fig. 3476), and description.

The following well-arranged, brief list of some of the more important chemical methods that have been tried I extract from Gray's Report, before alluded to:

"1. Processes that employ salts of alumina as the chief precipitating agent:

"The Coventry process. Crude sulphate of alumina, salts of iron, and lime."

"The Native Guano, or A, B, C, process. Alum, blood, clay, and animal charcoal." [In addition to these the original specification stated that magnesia, magnesia limestone, manganate of potash, chloride of sodium, and burnt clay might be added, and that vegetable might be substituted for animal charcoal.]

"The phosphate sewage process patented by Mr. David Forbes and Dr. Astley P. Price. Phosphate of alumina and lime."

"Bird's process. Sulphuric acid and clay."

"Stothert's process. Lime, sulphate of alumina, sulphate of zinc, and charcoal."

"2. Processes which employ lime as the chief precipitating agent:

"Hille's process. Lime, tar, salts of magnesium, etc."

"Marsden and Collins' process. Lime, carbon (a waste product of prussiate of potash manufacture), house ashes, soda, and perchloride of iron."

"Holden's process. Sulphate of iron, lime, coal-dust, and clay."

"Fulda's process. Lime and sulphate of soda."

"Blythe's process. Superphosphate of lime, with magnesia and lime."

"Whitthread's process. Dicalcic and monocalcic phosphate and milk of lime."

"Campbell's process. Soluble phosphate of lime."

"Hanson's process. Lime, black ash, and red hematite treated with sulphuric acid."

"Goodall's process. Lime, animal carbon, ashes, and sesqui-persulphate of iron."

"The Lime process. Milk of lime."

"General Scott's process. Milk of lime; the sludge being burnt, forming Portland cement."

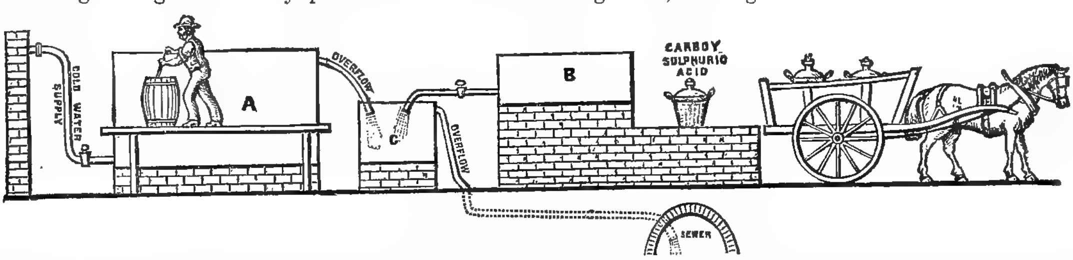

FIG. 3476.—Process of the Widnes Alkali Co., for Deodorizing the Contents of Sewers, by forming and mixing with them (as made) Permanganate of Soda. A is an iron tank about six feet by six feet by four feet, with cold-water supply-pipe and overflow-pipe. Manganate of soda is introduced into this tank, the cold-water inlet-tap opened, and the solution flows out of the overflow-pipe into the mixing vessel C, a small, lead-lined cistern about two feet by two feet by two feet. Here it meets with sulphuric acid from the lead-lined cistern B (about four feet by four feet by two feet in dimensions), the flow of which acid is regulated in such quantity as to turn to a bright pink color the manganate of soda solution from tank A. The manganate of soda solution is thus turned into a permanganate of soda solution in the tank C, and runs through the overflow-pipe at the top of C into the drain or sewer where it is required. The process is a continuous one, the manganate being fed slowly into A, while the inlet water-pipe regulates the rate of overflow to the required quantity.

"3. Processes in which salts of iron are used as precipitants:

"Chloride of iron and lime."

"Sulphate of iron and lime."

"4. Miscellaneous processes."

These processes are very numerous, but have led to no practical results. In England, from 1856 to 1876, there were four hundred and seventeen patents issued, all more or less connected with sewage and manures.

Of the many methods that have been tried for the chemical treatment of sewage, there are but three that stand prominent at the present time. These processes are those of "The Rivers' Purification Association, Limited [which controls and employs principally that which is], better known as the Coventry process.

"The Native Guano Company, Limited—better known as the A, B, C, process; and

"The lime process."

The precipitated "sludge" itself becomes a nuisance during the drying process; in order to get rid of the water (which generally amounts to about ninety per cent.), heated floors, blasts of air, and other artificial methods are resorted to. But one which seems more likely to prove satisfactory is the filter-press of Messrs. S. H. Johnson & Co., of Stratford, England (Fig. 3477).

"It consists of a number of narrow cells held in a suitable frame, the interior faces being provided with appropriate drainage surfaces communicating with an outlet, and covered by a filtering medium, generally cloth or paper. The interiors of the cells so built up are in communication directly with each other, or with a common channel for the introduction of the matter operated upon,

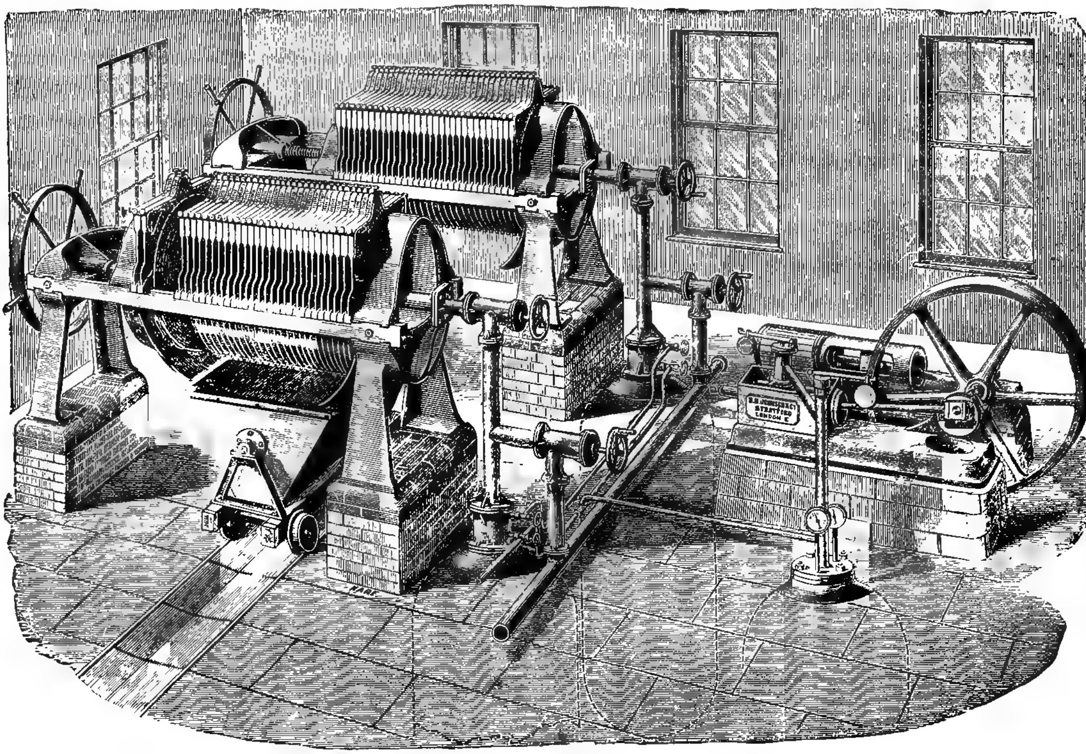

FIG. 3477.—Johnson's Filter-presses for drying Sludge.

and as nothing introduced into the cells can find an exit without passing through the cloth the solid matter fills up their interior, the liquid leaving by the drainage surfaces." The sludge is forced into them by the action of compressed air. The sludge-cakes are removed upon opening the press; they contain about fifty per cent. of solids and fifty per cent. of water, eight hundred parts per thousand of water having been forced out, leaving still one hundred of water and one hundred of solids.

The cost of the treatment of sewage by precipitation varies in English towns from seventeen cents to sixty cents per head of population per annum. But, as labor, chemicals, and apparatus are more costly in this country, we might have to double these amounts in order to obtain practical results here.

III. A COMPARISON OF THE ABOVE METHODS, AND THEIR ADAPTABILITY TO CITIES, VILLAGES, ETC.—We will now compare the merits of the various methods described, and their relative adaptability to the needs and circumstances of cities, villages, and isolated houses.

The Privy-pit and Privy-vault Systems.—It is hardly necessary in a work of this kind to describe at length the evils of the privy-pit: the poisoning of wells, the pollution of soil and air, the effects of the exposure of the nude person over a large pit full of cold and mephitic gases, the conveyance of germs of disease into the air and water, the general deterioration of health from taking into the body such air and water even when specific germs are not present—all these evils the medical reader should be able to comprehend and amplify for himself. I may, however, state a few facts illustrative of the extent of pollution from this cause. I was asked to examine, a few days ago, a site on which is to be erected an addition to one of our largest public schools. On one edge of the site a row of privies had existed; on the contiguous edge, about fifty feet distant, is an old well; the cellar excavation, about forty-three by twenty-eight feet, had been dug to the required depth of about seven feet. The structure of the soil is sand overlying a stratum of blue clay, with pockets of sand dipping into the latter. It was found that this entire area was a mass of stinking filth. How far beyond and around this filth extends I cannot say. The school has been supplied for some time with city water from Lake Ontario. A method of treating such a sewage-polluted site would be to remove all the soil down to the clay, to scrape the latter and flood it with a solution of bichloride of mercury, 1 in 500, and to lay a good concrete floor, the space between the clay and the concrete being previously filled with a mixture of clean clay loam and chloride of lime, or quick-lime; as an additional precaution air-spaces of porous tile, or brick arches, might be formed under the concrete floor, connecting with a hollow wall air-space outside the foundation at two sides of the building, one of these latter being connected with a furnace flue, the other communicating with the outside air. A contemporary issue of a newspaper in one of our country towns relates the following incident: "A short time since in making an excavation for a building, the workmen struck a vein of polluted earth, the stench from which was almost unbearable. Being curious to see and know the cause, I had the men follow the vein and found that it had its origin in a pit, and its outlet in a well, the distance to which was about one hundred and forty feet. In its passage the liquid matter from the pit had defiled the earth for several feet in all directions." Similar soil pollution exists around and amid dwellings in city, town, and country, everywhere, and we are occasionally aroused by unmaskings of what is continually, but secretly, going on around us. A calculation from actual facts will help to show the intensity of this evil: In some of the thickly inhabited portions of cities, even on this continent, we will find as many as five hundred people on a space of seventy by two hundred yards. Taking the basis, as given by physiologists, of two and a half to three ounces of fæces and forty ounces of urine per diem, for each individual, there is deposited in, and spread through, the subsoil of this area every year from fourteen to eighteen tons of fæces, and more than forty-five thousand gallons of urine, besides slop water, all which is left to slowly decompose for years without removal. It seems strange that such con-

Sewage.

ditions should have been so long tolerated, but the people at large are slow to act on the *dicta* of a few sanitarians until the facts and consequences have been made plain to them; they are slow to move out of old grooves, especially when private rights and convenience stand in the way. Moreover, proper disposal of sewage in communities requires combined action, and it is often difficult to get municipal corporations to act on scientific principles, especially when it is thought that a little false economy will better serve political interests. Medical men must persevere in their efforts to awaken the public to a realization of the extent and nature of the evil. Boards of health generally must follow the example of those boards which are bringing about a rectification of this evil.

In many places the work was begun by ordering the cleansing, filling, and replacing, by some proper substitute, of every pit or vault reported to the board of health and found to be a nuisance. In others the board has introduced and carried out, throughout an entire district, some proper system under its own oversight.

The privy-vault is somewhat less objectionable than the mere pit, inasmuch as it is at first water-tight; but there is great danger of soakage or of pollution of soil and water eventually occurring, and in the meantime the vaults pollute the air.

The Midden system is not to be commended. It is a very doubtful improvement over the old want of system.

Deposits of garbage in cities, towns, and villages are responsible for much sickness. Garbage—decomposable animal and vegetable matter, generally mixed with ashes and other rubbish—is dumped into hollow places, and after a time excavations are made in these. Sometimes the cellars and foundations of houses are constructed in this "made soil," and the ascensional current draws up the gases of decomposition from the soil. Occasionally the owner and builder are not aware of the nature of the site.

The diminution of mortality by the introduction of improved means of sewage disposal is shown in the following tables, and from it may be inferred a great decrease in the amount of sickness, and a consequent gain in material wealth:

City.	Period.	Sanitary condition.	Death-rate per 100,000 from typhoid fever.	Period.	Changes in sanitary condition.	Death-rate per 100,000 from typhoid fever.
Frankfort-on-the-Main	1854–59	No sewerage.	87	1875–80	Sewerage completed.	24
Dantzic	1865–69	No sewerage; no proper water-supply.	108	1871–75	Water-supply introduced.	90
				1878–80	Sewerage added.	18
Munich	1854–59	Absolutely no regulations for keeping the soil clean.	242	1860–65	Reforms begun by cementing the sides and bottoms of cesspits.	168
				1866–73	Partial sewerage.	133
				1876–80	Sewerage improved.	87
				1881–84	Sewerage still further improved.	17

Place.	Average mortality per 1,000 before construction of works.	Average mortality per 1,000 since completion of works.	Saving of life.	Reduction of typhoid fever.	Reduction in rate of phthisis.
			Per cent.	Per cent.	Per cent.
Banbury	23.4	20.5	12½	48	41
Cardiff	33.2	22.6	32	40	17
Croydon	23.7	18.6	22	63	17
Dover	22.6	20.9	7	36	20
Ely	23.9	20.5	14	56	47
Leicester	26.4	25.2	4½	48	32
Macclesfield	29.8	23.7	20	48	31
Merthyr	33.2	26.2	18	60	11
Newport	31.8	21.6	32	36	32
Rugby	19.1	18.6	2½	10	43
Salisbury	27.5	21.9	20	76	49
Warwick	22.7	21.0	7½	52	19

A large number of statistics illustrating this subject may also be found in a paper by Mr. Erwin F. Smith, published in the "Annual Report of the State Board of Health of Michigan" for 1885.

Water-carriage is undoubtedly the most preferable method in places where the sewage can be properly got rid of without further outlay, or where it can be utilized with little or no loss. It is quite possible that the time may not be very far distant when there may be some better and more intelligent understanding between the agriculturist and the sanitary authority, when there may be some such combination as will put an end to some of the difficulties and loss at present attendant upon sewage disposal and utilization. But accepting the fact that there is generally at the present day a small loss, this is counterbalanced over and over again by the gain to the community in the saving of life, time, and the expenses resulting from sickness and death. But as this saving is brought about in varying degrees by all sanitary improvements, we may briefly consider what are the special reasons for preferring the water-carriage system:

First, in all systems there must be some means of disposing of chamber, house, and kitchen slops; and, strange as it may at first sight appear, it has been found in large communities that the exclusion of excreta makes but a slight difference in the character of the sewage. From De Chaumont's edition of Parkes' "Hygiene" ("Wood's Library" for November, 1883, pp. 32, 52), the following remarks are quoted: "This difficulty is felt in the case of the foul water flowing from houses and factories without admixture of excreta almost as much as in sewer-water with excreta. The exclusion of excreta . . would indeed hardly lessen the difficulty—" . . "the solid excreta of only six per cent. of the inhabitants [of Birmingham] pass into the sewers, while the solid excreta of the remainder pass into middens. The problem of disposal is as serious for Birmingham as if all the excreta passed in." The conclusion of the Second Rivers Pollution Commission accords with this.

Secondly, after a proper building of the entire system, there is more perfect automatic action and less dependence upon individuals.

Thirdly, the conveniences are much greater, and the encouragement given to the liberal use of water conduces to health.

Fourthly, in a well-constructed system of sewerage all refuse, except garbage, leaves the community within a few hours of the time it becomes refuse; and garbage may, by individual household management, be destroyed in the same time.

Many persons have objected that the water-carriage

system makes avenues for the entrance of sewer-gases into houses. This objection holds not against the system as it should be, but against the faulty and defective contrivances that are too often allowed. How these defects may be obviated is shown in the articles on Habitations: General Principles of House Plumbing, and on Sewerage. To enforce correct principles in spite of the wilful neglect of avaricious and unscrupulous builders and tradesmen, we must come to a strict system of inspection of plans and buildings.

The groundlessness of the above objection to the introduction of systems of sewerage will be evident from the statistics already given and referred to.

Then, again, fears have been expressed regarding the salubrity of localities in the neighborhood of sewage farms, and regarding the wholesomeness of the products of the latter. On these subjects M. A. Durand-Claye quotes from a letter addressed by Dr. Frankland to M. Mille, inspecteur général des Ponts et Chaussées. "In reply to your letter of the 12th inst. [May, 1881], I will say that I have followed with the most lively interest the recent researches of your illustrious compatriot, M. Pasteur, and I consider them of the highest importance. . . .

"These considerations, however, have not modified my opinion as to the harmlessness of sewage irrigation; for its harmlessness has been proved by ample experience. . . . It has been recently proved by experiments in my laboratory, that although bacteria live and multiply in sulphuric acid, in cyanogen, and other deadly poisons, they are at once destroyed by that inoffensive material, metallic iron.

"That there may be in nature powerful agents for the destruction of the germs of disease cannot be doubted. . . . Experience seems to show that some of them are active in the process of sewage irrigation; for it has been demonstrated many times in this country that sewage, *even when infected by cholera and typhoid fever*, has never, when used in irrigation, transmitted disease, either to those living on the irrigation fields, or to those who consume the crops raised upon them."

Microscopic examination of Paris sewage, and of the effluent from the irrigation fields, shows the number of microbes per cubic centimetre to be twenty thousand, and twelve, respectively; and chemical analysis also shows a remarkable purification to have taken place.

Dry Systems.—The difficulties connected with the constant oversight required by the dry-earth, and dry-ash, and pail systems in a mixed community, will have been apparent, and the offensiveness caused by several days' storage, without deodorant, in the latter system, is an additional objection. In both, too, there is a continuous outlay.

There are, however, circumstances in which these systems may be advisable; as, for example, to serve a temporary purpose till the more permanent system of water-carriage and its suitable disposal can be introduced. In the case of railroad carriages, too, either the dry-earth or dry-ash method, or pail with disinfectant solution, should be employed; the present disgusting and unpleasant mode is well adapted for spreading typhoid fever and cholera, should the latter pass the maritime barriers. A resolution which aims at bringing about the substitution just indicated has been adopted by the American Public Health Association, at its recent meeting at Memphis, Tenn. (November, 1887), and should receive general support. In places where neither a suitable outfall nor land suitable for irrigation is obtainable, one of the dry systems for excreta, and precipitation for slop-water, may be employed.

Pneumatic System.—It was to meet the needs of places of this character that the Liernur system was introduced, but it is apparently an uncleanly and somewhat offensive method (see Sewerage), and has not met with much favor.

Disposal of Surface Water.—A question of a general nature presents itself for consideration: Shall we allow the surface water to enter the sewers? If we do so, instead of adopting the separate system of sewerage (see Sewerage), we so dilute the sewage and increase its quantity that we render its utilization (except under circumstances rarely met with) much more difficult and costly, besides increasing the cost of the sewers, and rendering them, as a rule, more likely to become foul in dry weather. If we do not allow the surface water to enter, what are we going to do with the horse-droppings and other surface filth? The question must be differently answered according to varying circumstances.

We are now in a position to apply the foregoing facts and principles to the various conditions of cities, villages, and isolated houses. In so doing individual opinion may differ somewhat, according to the objects which may seem to different persons to be of greatest importance, and according to the point of view from which they look at them.

In cities the water-carriage system is likely to prevail for the reasons already stated. Where an outfall into a body of water may be permitted without any of the evils of water pollution, and if the surface slopes toward the water-front, then the surface and rain water may be allowed to flow along surface channels in gutters (unless the volume is too great), and the separate system may be employed for sewage. If there is no suitable outfall, then the first washings (being more concentrated) may be intercepted by the sewers (see Sewerage), and the larger volume be excluded. If there be a sufficient quantity of suitable land near the city, irrigation or filtration may be resorted to. If distance or other reasons forbid this, then precipitation may be employed. In either case, while it is not well to stint people in the amount of water they use, it is well to prevent waste and leakage. In cities with large sewers, built for both storm water and sewage, especially when there is little fall, it is well to encourage the use of plenty of water, in dry seasons more particularly. If surface water is excluded from the sewers, road pavements should be built and frequently swept, and other roadways should be scraped clean. In employing irrigation, if there be a large quantity of light, suitable land near the city, and a good fall, we need be less sparing of the quantity of water entering the sewers than if the reverse conditions prevailed. While it is true that very light, sandy soil is well adapted for irrigation and filtration purposes, sand a few inches above the water, as on a lake shore, is of no use, however dry it may look. A few inches down the sewage stagnates in the water, and runs laterally instead of running off. Cesspools should never be allowed in cities, nor should vaults or pits. Where these two latter do exist the choice of ultimate disposal is between cremation along with the garbage, and the deodorizing and making of artificial manure. They should never be allowed to connect with the sewers, unless with vaults we include latrines with water-supply (see Sewerage). In cities which are very flat, and with broken surface, the use of Shone's ejectors should be borne in mind.

In villages with scattered houses, and in the isolated parts of cities, the dry-earth or dry-ash system may be used. But in compact villages the water-carriage system may well be employed. A central tank may be built and some form of pump used if there is not sufficient fall. Whatever mode is employed, it should at once be systematized, and corporation sanitary officials should have the oversight of it. The surface water may be left to look after itself—the filth per capita being smaller and the quantity of surface and subsoil water greater than in cities.

In isolated houses the householder can readily decide between the water-carriage and dry-earth or dry-ash systems, as to the mode best adopted to his surroundings, and the occupation of himself and his servants. If he has plenty of water and a suitable water-service, water-carriage with a small glazed sewer will be the best method. If he has not an outfall which will not be a nuisance to himself or his neighbors, he may employ irrigation or subirrigation on the cottage plan, described before. The tank must be protected from frost, and separated from the soil-pipe by a disconnecting trap (see Sewerage), or by a trap and vent-pipe. Cesspools should not be employed unless they are so situated that they cannot possi-

bly contaminate wells or the soil in the vicinity of houses. During the course of an investigation into the causes of typhoid fever in a large public building, I caused to be unearthed a cesspool, the existence of which was not known to the officers of the institution, who supposed the drain for the soil-pipe opened into the main drain. Sewage had been for a long time filtering into the basement.

For isolated buildings it appears as though the Smead-Dowd apparatus would serve the double purpose of carrying off foul air and disposing of the excreta.

In all cases the householder can greatly aid the sanitary authorities in the disposal of garbage, but in country places he ought to find no difficulty in utilizing it. It should be borne in mind that ashes make, with the wet earth, excellent hard walks.

In conclusion, I wish to express my indebtedness to the gentlemen to whom reference has been made in this article, for the assistance obtained from their writings.

Wm. Oldright.

Appended are some suggestions and a form of tender and specification which may be of some service in small communities where the dry-earth system has to be introduced. They are taken from a pamphlet issued by the Provincial Board of Health of Ontario for use in the Municipalities.

The following suggestions are made to Municipalities contemplating the establishment of the dry-earth system:

In the outlying portions of a town or village where garden space is ample, the householder may safely be allowed to procure the earth necessary and to dispose of the used earth as manure in the garden and fields. The sole duty of the Municipality will be to see that the old privy-pits are done away with, and proper dry-earth closets substituted, and to occasionally inspect the premises.

In the central and more thickly populated portions it will be necessary to make special provision for the supply and removal of earth. This may be done by contract or day labor—if by contract the contractor may be allowed to sell the resulting manure for his own benefit.

Perhaps the simplest and fairest method of meeting the expenses connected with this system would be for each householder to pay the Municipality for the earth delivered at so much per cart load, and for the earth removed in the same way; all the carts used in the work to be of exactly the same size, and to have their contents in cubic feet branded on the sides.

It might happen that, even in the crowded districts, many householders might find it preferable to use ashes instead of earth; in such cases, if payment were made in the manner above suggested the householder would pay simply for the removal of the product, *i.e.*, for the work required to be done, and for nothing more.

The Municipality may also make each person bear the expenses of the preliminary work done on his own premises, such as the cleaning and refilling of privy-pits, the building or repairing of privy-houses, providing earth-closets, etc.

As it would be difficult to include the repairs of existing privy-houses in a contract, such work had better be done by day labor, either by the Municipality or by the householder or owner.

In order to supply the earth, the Municipality might set aside, or purchase, a certain quantity of land, or else the contractor might be allowed to obtain earth at his own expense.

The earth removed should be deposited in such places as may be approved of by the local health officer, until such time as it is sold for manure.

A good shed should be built at the place where the earth is procured, under which a sufficient store should be kept in reserve, so as to tide over periods of stormy and wet weather, when the earth would otherwise be unfit for use.

It would not be necessary that the earth should be supplied and removed at stated periods. It will be found sufficient in general for each householder to notify the contractor or the local health officer of his needs as they occur, in order that they may be immediately attended to. This should be subject, however, to the discretionary power of the local health officers, for the whole system of earth-closets in the Municipality will, of course, be under the jurisdiction of the local health board.

With careful management the supply necessary may be reckoned at the rate of one cubic foot of earth per individual, per month, if used only once; but as the earth may be used several times without becoming offensive, the quantity required may be reduced considerably. However, where earth is plentiful this plan is not recommended.

It may be of assistance to individuals, and to municipal authorities, to have approximate information of the prices of automatic closets complete, and of closet fixtures. The prices asked are somewhat as follows:

Closet, for house use, neatly finished, all complete, and which can be placed in a vacant room or shed, ready for use, according to material and finish, about	$14 00 to $16 00
Commode closet, neatly finished, which can be easily moved from one room to another in case of sickness, about ...	12 00 to 14 00
Closet to be placed over a vault, plainly finished, with hopper	10 00
Fixtures for vault closets, with seat, about	5 50 to 8 00
Extra pail for the commode closet, for greater convenience	0 75

For quantities, for schools and public buildings, some reduction could be obtained from the above prices.

The following are proposed forms of specification and tender for the works connected with the system of dry-earth removal:

FORM OF SPECIFICATION

MUNICIPALITY OF ——.

Date..................

Dry-earth System of Removal.

The work to be done consists of the following items:

1. All privy-pits within the Municipality to be thoroughly cleansed and filled with clean earth, the number of the same being approximately ——.
2. The contents of the privy-pits to be removed to ——, where they are to be thoroughly mixed with a sufficient proportion of fresh earth (or ashes) to render the mass an inoffensive manure.
3. Earth-closets of some approved pattern, either patented designs or consisting simply of excrement- and dry-earth tubs placed under hinged seats, to be substituted for the former privy-pits.
(Clauses 4 to 12, inclusive, apply to thickly settled districts.)
4. Earth to be supplied for use in the closets, and the used earth or ashes, as the case may be, to be removed to a suitable place.
5. The earth supplied to be loamy in its nature. Earth difficult to screen or bring to a powdery condition will not be allowed to be used.
6. The earth to be obtained at ——.
7. The earth or ashes after use in the closets to be deposited at ——.
8. The quantity of earth to be supplied may be reckoned at one cubic foot per individual, per month, but this quantity may be lessened by the earth being used more than once, and also by the use of ashes.
9. The earth to be delivered and removed in carts containing —— cubic feet, having their capacity branded on the sides.
10. Sheds to be built on the premises of each householder, for the proper storing and screening of the earth, where none suitable for the purpose exist.
11. A suitable shed to be built at the place where the earth is procured, wherein a sufficient quantity is to be maintained to prevent scarcity in the supply, arising from the long continuance of weather during which excavation cannot be carried on.
12. The district to be supplied with earth contains about —— inhabitants, and is bounded as follows: ——
13. The prices for cleaning and filling privy-pits, providing earth-closets, building privy-houses and sheds, supplying and removing earth, ashes, etc., must include all the labor, tools, sheds, materials, land,* horses and carts, and all other appliances and expenses necessary for the proper carrying out the work.
14. The contractor will not be permitted to take advantage of any error or omission in the foregoing specification, as full instructions will always be given should any error or omission be discovered.
15. The work will be carried on under the inspection of, and subject to the approval of, the local health officer.
16. Payments will be made monthly, on the certificate of the local health officer, for all work included in this specification. In the case of the delivery of earth and removal of soil, the bills of the contractor, certified by the householder, may be accepted by the local health officer.

FORM OF TENDER.

MUNICIPALITY OF ——.

System of Dry-earth Removal.

	$ c.
Cleansing and refilling privy-pits, including proper disposal of contents, per pit	——
Earth-closets, patented designs, per closet	——
" " dry-earth tub, excrement-tub, and scoop, per set	——
Privy-houses, each	——
Sheds for storing and screening earth, etc., each	——
Supplying earth for use in closets, per cubic yard	——
" " " per load	——
Removing earth or ashes from closets, per cubic yard	——
" " " per load	——

The undersigned hereby propose and undertake to perform all the work, and furnish all the material, plant, etc., required for the proper performance of the same, in accordance with the specifications and advertisements dated ——, copies of which are hereunto attached, and are prepared to enter into a contract with the Municipality of ——, for the due performance of the same, at and for the rates and prices set forth in the foregoing schedule.

SEWERAGE. Under the heading Habitations: General Principles of Plumbing, the commencement of the water-carriage system, within the house, has already been considered; and in the article Sewage, Disposal of, the ultimate treatment of the contents of sewers has been dealt with, as well as the modes of disposing of refuse matter by other systems. In this article it is proposed to give such a consideration of the "water-carriage system" from the house to the outfall as may be of profit and interest to the medical reader, thus filling up the gap between the two articles above referred to. And while we are obliged, in order to attain this object, to glance over the field of the sanitary engineer, *minutiæ* of engineering will not be attempted.

PRELIMINARY CONSIDERATIONS.—In connection with the sewerage of any particular place, there are certain preliminary considerations which must be taken up.

* Where the Municipality has *not* set aside or purchased land for the purpose.

One of these has been partially discussed in the article on the Disposal of Sewage; I refer to the question of deciding between the combined and the separate methods of sewerage; nothing but excreta, laundry, and kitchen slops, and certain kinds of waste from manufactories and stables, being allowed to enter the sewers in the separate system, and in some cases enough of the rain-water from the roofs for flushing purposes; while in the combined system all the storm and surface water is also admitted.

The position and character of the outfall will have an important bearing upon the whole character of a sewerage system. If the outfall be such that we have to treat the sewage by irrigation or precipitation, this will be one element in determining some method by which only the concentrated portions will pass to the outfall, the superfluous storm-water being diverted into other channels.

The amount and character of the rainfall—whether equable or varying—will have to be considered, with a similar object in view. Heavy rains tax the capacity of the sewers far more than frequent gentle showers, even though the total annual rainfall may be more in the latter than in the former case.

The geological and physical nature of the soil will have a manifold influence; a sandy or loamy soil, especially if the slope be not great, will leave much less water to go into the sewers or down the gutters than a more impenetrable and steeply sloping one. The configuration of the soil may cause engineering difficulties, which again may enter into the determination of the system to be adopted; and the existence of rock or sand may present difficulties in construction or in permanence.

The area and population—present and prospective—will also have to be considered. With scattered population the difficulties are increased, especially those of the combined system. On the other hand, sufficient care is not always exercised in regulating the size of sewers to meet the probable growth of the sewerage system of a town or city.

The bearings of water-supply, of the *habits of the people*, and of the *sanitary appliances already in existence*, will be apparent. An abundant supply of water, with careless waste, may unduly tax the sewers, and unduly dilute the sewage; or a scanty supply may promote the liability to deposit.

THE FOLLOWING PRINCIPLES must be kept in view in connection with systems of sewerage:

All matters entering the sewers should be removed, and removed completely, to a suitable outfall (no lodgements, no leakage).

They should pass entirely from the sewerage system before there is time for decomposition to take place. The limit is often placed at twenty-four hours; but when we come to speak of velocity it will be seen that in the largest ordinary system not half that time will be consumed if the sewers are so constructed as to be self-cleansing.

There should be free ventilation through the entire system.

Means should be provided to direct the necessary escape of the gaseous contents to points where they cannot come in contact with human beings, and to prevent escape at points where they may come so in contact.

These principles, and violations of them, will be explained more fully as we now proceed to take up the various points in the construction of sewers.

CONSTRUCTION OF SEWERS.—The *materials* of which sewers are constructed.

Tiles answer well up to a diameter of eighteen inches or two feet. They should be of salt-glazed, vitrified earthenware; lead-glazed pipes chip, and allow soakage and leakage. Their strength may be tested by placing heavy weights upon them, or dropping weights on to them in a trench; they may be placed under a weighted lever, arranged like the arm which carries the weight of a safety-valve; or they may be laid horizontally with a block under each end and the weight applied in the centre. The best test, however, would seem to be by hydraulic pressure from the inside; sometimes pipes having fire-cracks and looking to be poor will stand this most natural test better than others whose appearance is not so bad. They should be true-fitting, for any defects in contour, such as shown in Fig. 3478, will affect the formation of joints and give rise to leakage.

FIG. 3478.—Pipe Defective in the Contour of its Socket End and making a Leaky Joint.

Fig. 3479 represents the form of tile most commonly used, having a socket at one end into which the other (spigot) end of the next pipe above is placed to make the joint.

Fig. 3480 shows a different form of pipe, without any socket—the joint being made by placing the ends of two pipes in contiguity inside the ring, Fig. 3481.

Fig. 3482 is a representation of Doulton's opercular pipe, which is of service in enabling a person to search for and remove any obstruction, as in faulty places where there is little fall, or where for some other reason stoppage may be feared. Jenning's access pipes (Fig. 3483) are plain at both ends, and are laid in chairs (C) similar to the metals of a railway, the pipes being kept six, nine, or twelve inches apart, according to the diameter. They provide for the same object as the last-named pipe, and they have the advantage that, on lifting the upper part of the saddle, a pipe may be lifted out and a junction inserted to allow of the connection of another line of sewer at any subsequent time. The saddles may also be so placed as to allow of the passage of subsoil water beneath the pipes. They present one serious defect, however; the invert, or bottom, does not present an even, smooth surface, and cannot be made to do so, although an attempt be made to fill in with cement; it might be improved by a raised piece in the centres of the chairs or saddles. Other forms of tiles are used, but those above described are the best suited for practical purposes.

FIG. 3479.—Socket Pipe.

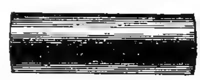

FIG. 3480.—Ring Pipe.

FIG. 3481.—Ring.

Iron pipes must be used when a larger size of pipe is required, or when any unusual strain or pressure has to be borne, as where there is a long or heavy lift in pumping, or where some stream or chasm has to be crossed. They should be tested and examined, in the manner above described, for brittleness and defects in their walls and contour. They are sometimes enamelled inside when used for house connections; but for such purpose, where there is no heavy pressure or strain, the glazed tiles are preferable.

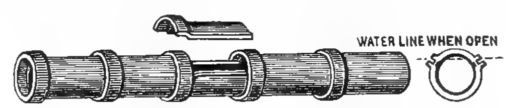

FIG. 3482.—Doulton's Opercular Pipe.

Brick must be the chief material for large sewers. The bricks should be very hard and impenetrable, especially for the invert, to withstand the grinding friction of the passing contents. Their strength may be tested by a weighted lever, as above described in the case of tiles. Their porosity is a very important point, and may be tested by weighing them when kiln-dried, and again after soaking in water. Great care should be exercised in seeing that they are built with good (water-proof) ce-

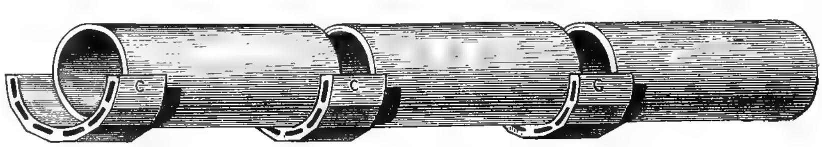

FIG. 3483.—Jenning's Access Pipe.

Sewerage.

ment, that the joints between the bricks are smooth and even, and that the sewer is not covered in too soon, before the joints have had time to set and harden.

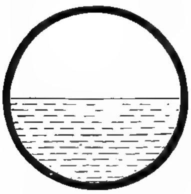

FIG. 3484.—Circular-shaped Sewer.

Concrete and artificial stone have been used, but not very extensively, nor with much success.

Wood. The too common practice of using wooden box-drains must be condemned, unless as a temporary makeshift. Sometimes a form of barrel-drain, bound with metallic hoops, is used. This protest against box-drains might seem to be superfluous; but it is not more than five years since it was found that, in a city afflicted with an epidemic of typhoid fever, one of the main sewers was a box-drain, with no bottom (except the earth), the sides being held together by pieces of scantling laid on the earth. With this were connected the drains of cesspools and houses, some of the latter of wood and untrapped.

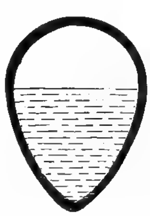

FIG. 3485.—Ovate-shaped Sewer.

The *shape* of sewers is a very important consideration, and must vary according as the flow is expected to be equable or variable; if equable, the circular form (Fig. 3484) is to be preferred, because it gives the greatest capacity with the least expense of wall. Hence it is almost exclusively used in the separate system of sewerage. If the flow is variable, the ovate shape gives the advantage of the deep narrow stream; and when the quantity of sewage is small, deposit is less apt to take place. Hence the use of this shape in the combined system. In old times sewers had to be cleaned out by scavengers, with the same regularity as chimneys were swept. The bottoms were broad, flat, and uneven; the slow, sluggish streams allowed deposits to be formed, which quickly increased by their own impeding action. The same plan is commonly followed with box-drains (Fig. 3486). In cases where they are employed (and it should only be temporarily), they should be set angle down, so as to give the fluid its greatest possible depth and force, and prevent deposit.

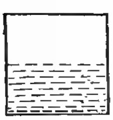

FIG. 3486.—Box-drain laid flat, with Deposit accumulating.

Joints have been incidentally described above as regards their modes of formation, when a description was given of sewer-pipes. They should be true fitting, so as to prevent gaps out of which the cement or clay may fall or be forced. Care should also be taken to prevent the apposed ends from losing their concentricity when laid: if the joints be fitted with puddling-clay or other soft material, this will give way under the downward pressure of the small end of the pipe, until this latter rests directly on the receiving collar of the next pipe, leaving no space between them on the under wall, but a large gap on the upper (Fig. 3488). This will be especially the case if no spaces have been cut to receive the shoulders. To prevent it the joints should be stuffed with oakum, and then with puddling-clay or cement, or, if the pipes be of iron, with lead, and should be thoroughly calked. This method of making joints will also prevent the filling of cement or lead from running into the inside and forming a nucleus for deposit. It will also help to prevent the intrusion of rootlets of trees, which are apt to insinuate themselves and cause accumulation and choking. Some persons try to kill rootlets by mixing bichloride of mercury in the filling. This is a poor expedient at best.

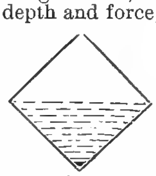

FIG. 3487.—Box-drain placed angle down, so as to avoid Deposit.

FIG. 3488.—Defective Joint; no packing having been used, the spigot end has displaced the cement and left an opening above.

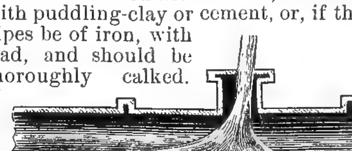

FIG. 3489.—Improper Junction.

Junctions of sewers, whether they are in a vertical or horizontal plane, should not be at right angles (Fig. 3489), as the interruption of the stream and the eddies thus formed will cause deposit which, when once commenced, will rapidly increase. The tributary stream should be made to enter in a course somewhat parallel to that in the main sewer (Fig. 3490).

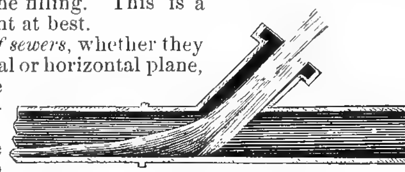

FIG. 3490.—Proper Junction.

For junctions, **Y**-pipes (Figs. 3490 and 3493) and **V**-pipes (Fig. 3492) are manufactured. The use of the **T**-pipe (Fig. 3491) should be for inspection holes and ventilating openings. The **V**-pipe is used where the main drain is made of two branches uniting, and flows in a direction between the lines of the branches; two branches should never run into a third drain with their mouths opposite to each other; one should enter a little lower than the other.

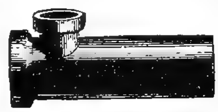

FIG. 3491.—T-pipe, for Use in Ventilating and for Inspection Openings.

Where a small sewer-pipe has to be received into the socket of a larger one, an "increasing-pipe" (Fig. 3494) is used to prevent a bad joint, which would be made if the gap were filled with cement and pieces of brick or stone. Fig. 3495 shows the reverse, or "diminishing-pipe."

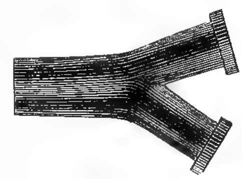

FIG. 3492.—V-pipe, for Junction where the Main Drain runs in a Direction different from that of either Branch.

The *direction* of a sewer should be as straight as possible, so as to retain the velocity. If it requires to be changed, gradual curves should be made. It sometimes happens that an impediment or junction may require a slight deflection. An "offset" (Fig. 3496), or "bends," "quarter-bends," or "elbows" (Fig. 3497), may then be of service.

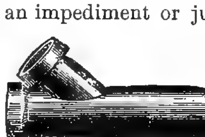

FIG. 3493.—Y-pipe.

The *foundation* or *bed* of a sewer should be firm and solid, so as not to permit of any breaking or disjointing. If pipes are used, small excavations should be made to receive the shoulders, so that these shall not have to bear the whole weight of pipe, contents, and superincumbent earth, with no support to the rest of the pipe, which is then liable to break or crack. Provision should be made for carrying away subsoil water, which is liable to make for the new earth formed in digging the bed of the drain. If the drain lie *in* a porous stratum and *over* an impenetrable one, the chances of the water running along its course will be especially great. Some tiles are made with a subsoil space, porous or perforated, so as to carry off this water. Fig. 3498 represents a sewer made of artificial stone in this way, in which the sewer, *A*, and subsoil space, *B*, are all in one piece; *C*, *C*, *C*, are small orifices through which the subsoil water makes its way into the subsoil space. Invert blocks with subsoil space are also made separately for the bottoms of brick sewers, which are then built upon them.

FIG. 3494.—Increasing-pipe.

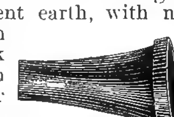

FIG. 3495.—Diminishing-pipe.

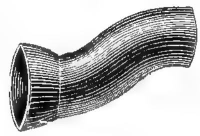

FIG. 3496.—An Offset.

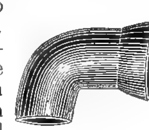

FIG. 3497.—Bend, or Elbow.

Want of attention to the foundation of sewers, especially where tiles are used, is one of the most common causes of deposit and of sewage pollution of the soil; then decompositon occurs, and foul gases are evolved. The writer has seen rows of houses rendered untenantable from the occurrence of diphtheria and other zymotic diseases from this cause. In one instance, where a sewer had been laid in sand, it had to be taken up in less than a year; the sewer had assumed a zigzag outline, and the tiles were choked with sand and sewage.

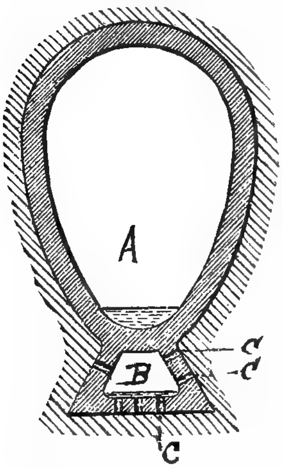

FIG. 3498.—Sewer-pipe of Artificial Stone, with Subsoil Space.

The *velocity of the stream* in sewers is dependent, not only upon the slope or fall, but also upon the shape, size, smoothness, and evenness of surface and the volume and equableness of flow. The ordinary velocity required will also depend upon the nature of the matters to be carried and the facilities for flushing. Some of these interdependent points have already been considered.

The *size of the sewer* requires careful consideration on the part of the engineer. If the sewers are too small there will be flooding of the connections with the lower portion of the insufficient sewer or system of sewers; if too large there is needless expense, and, what is of greater importance, there may be deposit from sluggish flow, and there will be a larger space for sewage exhalations to form in. I know of an institution with about five hundred inmates, situated about one hundred yards from the edge of one of our great lakes, which has two five-foot brick sewers to carry off its sewage! They were built in the good old times, and by convict labor. Fortunately, they had a short and rapid fall. The invert of one of them subsequently made a good foundation for a one-foot tile sewer which was recommended to be put in.

It has been found by experience that it is not well to have sewers for a mixed population smaller than nine inches, as they are very liable to obstruction. In Memphis, I am informed by Colonel Merriwether, City Engineer, that it is a common thing to find them obstructed by the carpenter's rule with its six-inch joints.

Mr. Baldwin Latham, in his work on "Sanitary Engineering," gives formulæ and tables for computing the velocity in sewers of various slope, size, and volume. He also states the results of a number of experiments for determining the carrying power of sewer-streams. From these it would appear that, for efficient house-drains, a velocity of three feet per second is necessary; and that this would require, in a nine-inch drain, a fall of 1 in 206; in a six-inch, 1 in 137; and in a four-inch, 1 in 92; and it is presupposed that the drains would run half full. The quantities of sewage discharged under these circumstances will be 39.76, 17.66, and 7.85 cubic feet, respectively. When running full they are capable of discharging double these amounts, but the velocity and scouring force will not receive any further increase. The point to be borne in mind is, that if the sewers cannot obtain sufficient fluid to half fill them, the slope must be greater. In the case of street-sewers it will be evident, on consideration, that it is in the upper ends that the least volume of sewage will be found, and hence the most natural position for flushing apparatus—the head of the sewer—is that where it is most needed; the size, too, may here be less, and this will add to the facility for flushing.

For *flushing*, various devices are in use. One very extensively employed is Field's automatic flush-tank, represented and described in the article on Sewage, Disposal of (see Fig. 3475). Somewhat similar is Van Vranken's flush-tank (Fig. 3499). The lower end of the longer or descending limb of the siphon is constantly immersed in water contained in a small tilting-tank, hung in a chamber below the bottom of the main tank. The drain is connected with this chamber. When the water rises in the main tank as high as the arch of the siphon and trickles over into the tilting-tank, the centre of gravity in the latter is changed, and it tilts over to the position shown by the dotted lines; the level of the water in it is suddenly lowered about an inch, and this starts the siphon action by which the main-tank is rapidly emptied. With both these tanks the intention is to allow them to fill slowly by a small trickle of water; by experience this can be so adjusted as to fill them once or twice in the twenty-four hours. In some places suspended matter in the water interferes with this intention. The tanks hold from one to two hundred gallons each. It is found that only about two per cent. of the total water-supply is required for flushing.

In valve-tanks (such as Pierson's tank) the valve is displaced from the outlet by a float attachment. In collapsing-tanks the sides collapse by the sudden filling and sinking of a floating vessel.

Large tilting-tanks and flushing-gates are also employed. They may be operated by automatic mechanism.

Flushing-gates are sometimes placed in the courses of sewers at long distances from their heads, the sewage itself being the flushing medium. It should be borne in mind that such an arrangement is liable to cause deposit above the gate, and that the scouring action is exerted below, and not to any appreciable extent above, the point where it is situated. Hence this method is not to be recommended.

In some sewers, where only a very slight fall can be obtained, flushing all along the line of the sewer has to be resorted to. In Chicago, for example, a "pill" (to be explained presently) is placed just above the man-hole opening, and the contents of a flushing-cart are poured down the latter into the sewer.

Cleansing of sewers by other methods has sometimes to be resorted to, notwithstanding the fact that the aim of sanitary engineers is to so construct them that they shall be self-cleansing. To facilitate the task of keeping

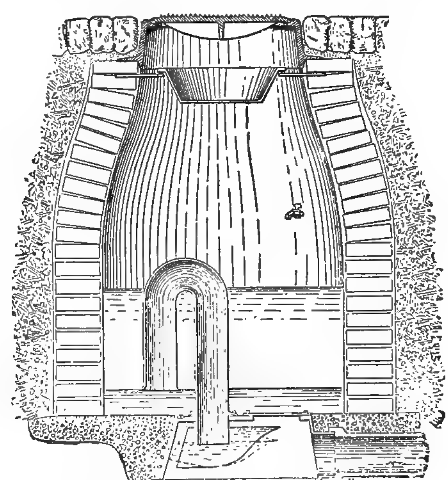

FIG. 3499.—Van Vranken's Flush-tank.

sewers clean, man-holes, inspection openings, lamp-holes, and cleansing openings are constructed.

Fig. 3500, copied from Dr. Ford's article in Buck's "Hygiene," shows a form of man-hole with ventilating grating and dirt-box adopted by Mr. Denton. It is provided with steps for descending to the sewer-pipe with which it is connected.

Another form of man-hole and ventilator (Fig. 3501) will be described when we come to speak of the ventila-

tion of sewers. The object of these man-holes is for workmen to descend, inspect the sewers, and cleanse them. This is done by means of various kinds of scrapers, rakes, hoes, drills, screws, balls, brushes, hooks, etc., which may be mounted on jointed rods such as those used by chimney-sweeps. Even with the sewers of the separate system, specially designed to avoid deposit, and flushed daily, it is found necessary, in Memphis and elsewhere, to use periodically the "pill" and brush. The "pill" is a hollow water-tight globe of thin metal, made three inches smaller in diameter than the sewer. The end of a rope is attached to a staple on one side of the pill, which is lowered down a man-hole or inspection-opening into the sewer and allowed to float (still held by the rope) down to the next opening. The pill may be held, or drawn back a little, at any point, and the volume of fluid, being obliged to pass through the three-inch crescent beneath it, will scour away any movable deposit. As soon as the pill reaches the next opening, a brush may be attached to the other end of the rope at the opening above, and drawn through the portion of sewer which has just been traversed by the pill.

Observation- or inspection-openings have been sufficiently explained in the above description. They are, of course, smaller than man-holes.

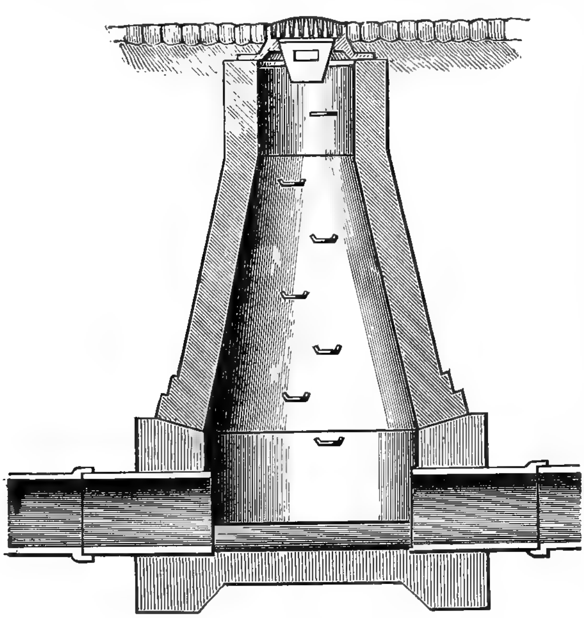

FIG. 3500.—Man-hole Connected with Pipe-sewer.

Lamp-holes are still smaller; they are generally constructed at no great distance from the man-holes, and are for the purpose of literally throwing light upon the intervening portion of sewer. The absence of light will indicate complete obstruction.

Sometimes cleansing- and flushing-openings are made to enter the sewer at obtuse angles with the portions below them. In this way a flushing-hose or cleansing-tool may be introduced through a comparatively small and inexpensive opening.

In some of the older sewers of the combined system, pits have been left in the invert at the bottom of the man-holes, for the purpose of collecting, and periodically removing, deposit. This is not to be recommended, as it favors deposit, which, if neglected, forms a nucleus, and which by its decomposition gives off offensive and injurious gases rising into the street. Similar pits are also made, in the course of the small sewers of the separate system, below stables and other points where obstructions have, in the experience of the officers, been found to result from the habits of careless people. The writer has seen plans of these, with their contents graphically depicted, and labelled as "Sardines," etc. (the "Sardines" were empty boxes, of course). Care must be taken to have these pits frequently inspected and cleansed.

In some of the large Paris sewers trucks were made to run, with the wheels on platforms, on each side of, and above, the sewage-channel, while a sort of gate the shape of the sewer-channel dips into it; this is carried along by the sewage and shoves deposit in front of it, while it also carries along the truck to which it is attached. When the deposit in front obstructs the action of the gate, the dirt is scooped up into the truck.

Ventilation of Sewers.—I have endeavored to point out the methods in the construction of sewers by which we are to avoid the retention of decomposable material, and to so cleanse the sewers that foul gases will be reduced to a minimum. But it has at the same time been made manifest that we are still liable to their formation.

Among the gases more commonly evolved from sewers may be mentioned sulphuretted hydrogen, carbonic acid, carburetted hydrogen, nitrogen, and ammonia. Many cases of asphyxiation in sewers and cess-pits are on record; no less than eight deaths from this cause occurred in the sewers of Chicago in one year.

The rise and fall of sewage, with the alternate wetting and drying of the walls of the sewers, cause a continual evolution of vapor. It is no conclusive proof of the absence of sewer-gases that they cannot be perceived by the sense of smell. Some injurious gases reveal themselves unpleasantly to the nose, while others do not. These last are so insidious in their nature as to be doubly dangerous. As examples, the baneful results which ensue from living in houses under which water lodges and becomes stagnant may be referred to. There are few medical practitioners who have not witnessed these results. The miasmatic poison of ague is inodorous, or has no necessarily unpleasant odor. In like manner sewers have sometimes very little unpleasant smell. Sometimes there is a smell somewhat similar to that produced by those burning fluids into the composition of which fusel-oil enters. We must be very careful, therefore, how we accept negative evidence as to the presence of noxious gases. In the experience of most practitioners, living in sewered districts, instances are common of the occurrence of zymotic diseases, clearly traceable to the presence of sewer-gases, where there has been little or no unpleasant smell. I am not aware of any appreciable odor from the contagia of scarlatina and measles, and yet they act through the medium of the atmosphere. One or two specific instances, in proof of what has now been stated, may be mentioned when we come to speak of some particular defects in sewerage. It is evident, then, that every care must be used to establish a thorough ventilation of sewers, and to secure it in such a way that the gaseous contents shall not, in making their exit, come in contact with human beings. Too often, and by too many avenues, they find their way into dwelling-rooms. How this should be avoided has been pointed out in the article on Habitations. It falls within the scope of the present article to point out the means commonly employed for the ventilation of sewers, the pneumatic forces which are at work in them, and the means which, in the opinion of the writer, should be adopted to change the air in them as frequently as possible.

It will be found that most of the agencies at work in sewers are variable and alternating in their action, sometimes drawing air into the sewer, and sometimes expelling gas through the same opening. The principal of these agencies are, besides the natural diffusion of gases, the following:

Difference of temperature between sewer and external air, causing an interchange in accordance with the laws which regulate the movements of unequal weights of air.

Upward draught in houses, acting as a ventilating shaft, in the wake of which the sewer-air will follow if allowed; sometimes a full flow of water down into the sewer will cause a current of air to accompany it.

The expansion force created by the sudden accession

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of heat in the drain, viz., by pouring down hot soap-suds of boiling water. This expansion is equal to 1 volume in 491 for each degree of Fahrenheit. As air expands the pressure is increased. If the temperature of the air in the drain be raised from 50° to 150°, the result will be

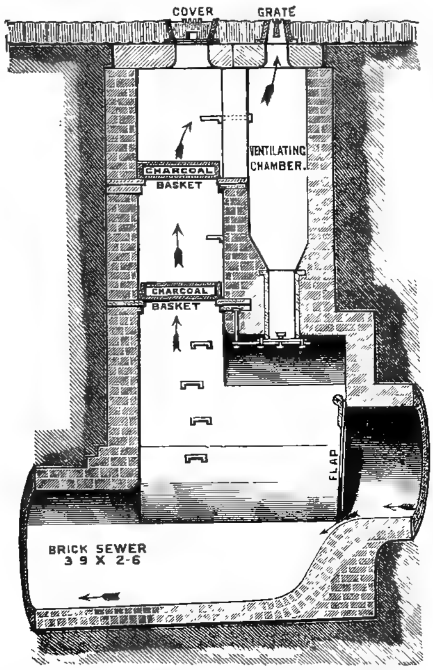

Fig. 3501.—Rawlinson's Manhole Charcoal Ventilator, and Tumbling-bay.

pressure equal to that of $6\frac{7}{10}$ feet head of water. And this rise of temperature is not at all an improbable one.

The flow of water into the drain causes an expulsive force. When water is poured into a drain it must, of course, displace its own bulk of air (less the small amount gained by compression), for two bodies cannot occupy the same space at the same time. Out of which end of the drain (supposing that it has no ventilator) this air shall pass will be determined by circumstances; it passes most readily where it meets with least resistance, always giving preference to an upward direction, owing to the greater gravity of the water. Storm-water suddenly filling the sewers acts powerfully in this way. This ebb and flow operate like a double-acting piston or syringe. Partial choking of the drain gives rise to confined air constantly increasing, expanding, and being displaced. Tides have a similar action. Wind blowing up the mouth of a sewer will drive gases before it; wind blowing across its mouth will often produce a down current.

From the rising of sewer-gases to the upper ends of sewers the higher, and at one time more healthy, portions of towns and cities have sometimes compared badly with the lower portions which have been improved *pari passu*.

Until lately the principal dependence for the ventilation of sewers has been on the ventilating gratings in the road-bed, both as inlets and outlets. Sanitary engineers, having experienced the necessity of deodorizing the air exhaled from the sewers, have invented and patented ventilators containing charcoal. One of these, Mr. Rawlinson's, is shown in Fig. 3501, which is copied from Dr. Ford's paper in Buck's "Hygiene." An inspection of the diagram shows the course taken by the sewer-gas. The man-hole has a tight cover to keep the charcoal dry. Below the ventilating chamber is a space for collecting the dirt which falls in, and which may be removed by unscrewing the plate at the bottom of the space. The flap-valve and bay are for the purpose of directing the gas up the ventilator, and the tumbling-bay is for the purpose of getting rid automatically of any deposit which may be caused behind the flap-valve.

Mr. Baldwin Latham gives a figure and description of a spiral charcoal ventilator (Fig. 3502), invented and thus described by him:

"The larger sizes combine in themselves man-hole cover, lamp-hole, and ventilator, while the smaller sizes fulfil the two last offices. Each of the large ventilators consists of four parts:

"1st. The frame *a*, for receiving the cover, and on the bottom of which hangs the dirt-box and charcoal ventilator.

"2d. The cover *C*, the centre part of which is solid, so as to form an efficient cover for the charcoal and protect it from rain, or the water used in street watering; *g* is the open grating in the cover by which air escapes or is drawn into the sewers. The openings of this grating are arranged concentrically, and are formed with the aperture wider below than at the street level, so that mud is not likely to adhere, or, if it does, is soon removed and falls directly into the dirt-box immediately below the grating. The cover in the illustration is shown filled in with wooden blocks (placed endways of the grain), for deadening the sound and giving an efficient foothold for horses. The covers, however, may be filled with any other suitable material, such as stone, concrete, or asphalt.

"3d. The dirt-box *d* hangs in a groove, *x*, made in the lower part of the frame *a*. The dirt-box is circular on plan, and the groove *x* is intended to be filled with fine sand. The weight of the dirt-box and ventilator pressing into the sand forms a gas-tight joint; *h*, *h'*, are handles attached to the dirt-box for raising or lowering it; *S* represents an open spiral trough which forms part of the dirt-box, and which is used for conveying away the overflow-water from the dirt-box to the sewer; *o* is a slot in the side of the dirt-box, communicating with the upper portion of the spiral trough, through which the water enters the trough.

"4th. The spiral trays *t*, for containing the charcoal, which are screwed into the ventilator over the spiral

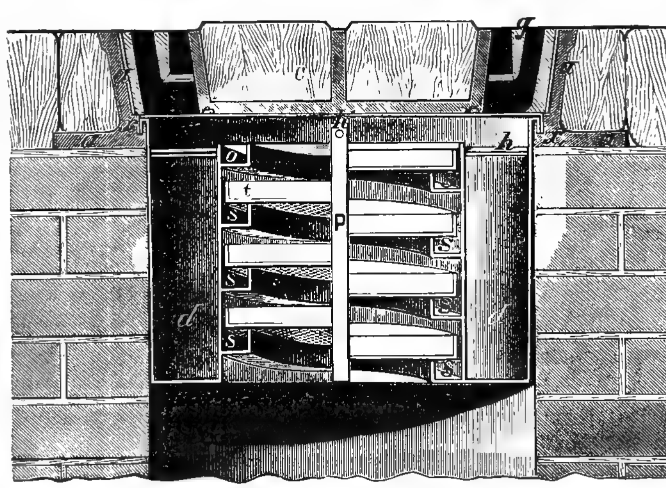

Fig. 3502.—Latham's Charcoal Ventilator.

trough *S*, by means of the handle *h*. Each tray consists of a central shaft *P*, which is square, and out of every face project arms of **T**-iron. These arms are attached at the extremities by a strip of iron coiled spirally, and the bottom of the trays is filled in with network.

"To recapitulate the advantages of this ventilator: 1. That, should the charcoal concrete in the tray, or if its pores are stopped with dust, no impediment is offered to

ventilation, as there exists a free communication between the sewer and the external atmosphere. 2. That the charcoal is completely protected from rain or water entering the ventilator or leaking through the joints of the cover, consequently it will retain its efficiency for a long period. 3. That the passage provided for the overflow-water from the dirt-box is not dependent upon traps, or any other uncertain device needing assistance to maintain it in perfect working order. 4. The escaping vapors are all brought in contact with the charcoal, it being impossible for any to escape by the sides of the tray or in any other way."

These charcoal ventilators are now mostly discarded as impeding the passage of air, and the contention of engineers often is that they are generally inlets; but the frequent stench, and the steaming exhalations from them in heavy winter days—exhalations through which our boys delight to run—do not support this contention, but rather go to show that the surface of the road-bed, amid the traffic of street passengers, is not a safe place in which to discharge these gases.*

As regards charcoal trays, even were the charcoal constantly dry, sewer-gas at times makes its exit too rapidly for the charcoal to exert any action upon it; so that, however useful an adjunct charcoal may be, it cannot be considered a preventive to the injurious effects of sewer-gas, and we cannot rely upon it as a germicide.

At one time it was a common practice to have the openings from the gutters untrapped; but as these openings were noticed to be very offensive, and were nearer to the foot-walks, they have been provided with traps. (See below.)

Laying aside the propriety of having such a point of escape for sewer-gases, it will be evident on consideration that the size of the street-gratings is insufficient, even when they are open; in our northern climate many of them are at times closed for weeks together, and they are often partially clogged with mud. But even when open, their interstices, if combined, would yield about forty-nine square inches, and if allowance be made for friction in the little openings, their carrying capacity would be about equal to that of a five- or six-inch pipe, and this to ventilate a length of six hundred feet (the distance given by Mr. Latham) of average street sewer.

Hence, it seems evident to me that the principle which is now being advised and adopted by leading sanitarians and architects, for the safety of the individual householder in regard to his house-drain, ought to be advised and adopted by sanitarians and engineers for the safety of the whole community in regard to the street sewers. A four- or five-inch pipe should be carried from every house-drain to the roof of the house which the drain is intended to serve, and should discharge the sewer-gas at a sufficient distance from all chimneys, windows, doors, or other openings into the house. Between this pipe and the sewer no trap should intervene. And this is the plan now generally adopted in Memphis and some other places, sewered on the separate system, there being no trap, save in exceptional instances, between the sewer and the soil-pipe extended above the roof. In the state of plumbing practice still in existence in many places, it would, in my opinion, be better to have a trap between the pipe and the house, provided that, in addition to the extension upward from the soil-pipe there is another four-inch pipe, forming a counter-opening and allowing a current of air to circulate freely through the house-drain and its connections and vents; but wherever good plumbing and rigid inspection are insisted upon, this multiplicity of pipes and traps could, and should, be done away with. There would then be a direct passage from the sewer to a point above the roof, carefully removed from chimneys, doors, windows, and all other openings into the house. Colonel Waring is a strong advocate for the abolition of traps on house-drains, contending that they impede ventilation and are themselves sources of danger.

It must be borne in mind that by the plan advocated the air allowed to escape through the soil-pipe (or outside vent-pipe) is not the same concentrated foul gas that often arises through street-gratings, for the number of openings, each of them almost of the same capacity as a (subdivided) manhole-grating, is so great that the gas is very much diluted; in a closely built street, with houses on each side of from twenty-five to fifty feet front, there will be one such opening for every twelve to twenty-five feet—instead of every six hundred feet, the limit for street-gratings given by Mr. Latham. Of course, this system, when adopted, should be made general. In places already sewered it could be introduced by the corporation authorities putting in ventilating pipes at such distances as would give some relief, and passing a law requiring that every new house-drain, and every drain that shall need to be reopened, be ventilated in this way, and that within a reasonable time the same shall be the case with all house-drains.

It has been objected that, inasmuch as house-drains do not usually enter the sewer at the highest point of the latter, there is a space in the crown of the street sewer that cannot be ventilated through the house-drain when the water in the sewer is higher than the mouth of the drain. To this I would answer that the air being confined to the crown of the sewer, its temporary stagnation during the time of flood-water will do no harm to anybody; if the pressure becomes very great the gases will be dislodged and will be carried off at a point higher up the line of sewer, where the drains are not water-locked; it is only at times that the house-drains will be so full as not to allow of counter-currents and through-drafts; and there is nothing to prevent the house-drains from entering sewers close to the crown, if so designed.

It has also been objected that air will not enter the sewers down the long stand-pipes; so long as the gas, when it does move, moves off overhead, we need not so very much mind its remaining in the sewer for a short time. But, as a matter of fact, a careful consideration of pneumatic laws and of the forces acting in sewers will show that the objection does not hold. The columns of gas or air on opposite sides of the street, if they are of the same temperature and density, will counterbalance each other; but let the sun shine on one side, and immediately an ascensional action begins; or let a cold wind blow on the other, and a dense column begins to descend. Besides, the rising and falling of the liquid in the sewer will cause the gas to be expelled, or the air to be drawn in. Again, the air will blow up the sewers from their mouths; and, for this reason, flaps should never be placed on the mouths—free vents being made all along the course of the sewer—although the contrary practice is recommended by some engineers.

Various contrivances for propelling air into sewers and extracting gases from them, such as fans, pumps, steam-jets, and furnace chimneys, have been employed. They are costly, and, alone, are insufficient and unsatisfactory. When plenty of free vents and good traps exist they are unnecessary, and when these do not exist they are dangerous, inasmuch as such propulsion will force traps, and such extraction will empty them by suction where free vents do not exist.

The true plan seems to be to make plenty of breathing-holes, plenty of channels through which currents will continually pass, and which will discharge gases at a safe distance overhead.

In many of our larger cities sewer ventilation is quite insufficient and faulty, and much apathy—or rather a want of appreciation of correct principles—is found in regard thereto. It has therefore been thought a subject which should receive here a full consideration.

Yard- and Gully-traps.—In discussing the means to be adopted inside of houses to secure the exclusion of sewer-gases from dwelling-rooms, various forms of traps

* On the day after the above was written the writer was called to visit a patient living near the head of a street in one of the finest districts of the city. Persons residing in the neighborhood have made loud complaints regarding the stench arising from several man-holes in this street and a street which crosses the head of it. At times, when a south wind is blowing, windows are kept shut and children cannot be allowed out to play in the immediate locality. Complaints have been made to the Medical Health Office regarding the matter. Numerous other instances of this kind might be reported did space permit.

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have been described, and the methods and principles by which their efficiency is to be maintained have been dealt

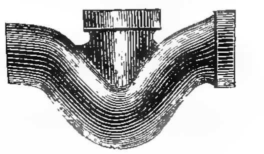

FIG. 3503.—Trap with "Hand-hole" in Centre; not suitable for drain with floating filth.

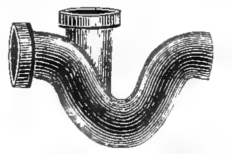

FIG. 3504.—Trap with Hand-hole on the Upper Side of the Seal.

with. (See Habitations: General Principles of Plumbing.)

In dealing with the means of excluding sewer-gases from frequented places out of doors, it only remains, therefore, to describe some forms of traps applicable to these places. Fig. 3503 shows a form of glazed-tile trap very suitable for a drain conveying rain or other water free from floating filth. Pipes may be brought from the hand-hole in the centre up above the ground-level, for the purpose of observing and removing deposit.

FIG. 3505.—Trap with Hand-hole below the Seal.

Filth in such a trap might remain floating for a long time in the hand-hole above the current, and hence it is not suitable for a house-drain.

Figs. 3504 and 3505 show traps more suitable for conveying floating filth. If the hand-holes are to be used merely for removing obstructions (should they occur), their sockets should be plugged and cemented; by means of pipes the openings may be brought up within a foot or two of the surface. But these hand-holes may also be used for purposes of ventilation, and for protecting the seals of the traps from accidents explained in connection with house-traps, due care being exercised as regards securing a sufficient supply of water.

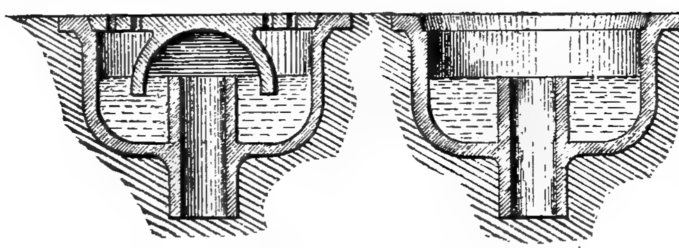

FIG. 3506.—Bell-trap Sealed and Unsealed.

Fig. 3506 represents a "bell-trap;" to the left it is seen with the seal perfect, and in the centre the seal is broken, the "bell" (to the right) having been lifted out. This constitutes a great objection to the bell-trap; the grating becomes clogged, or the space below becomes filled with dirt, and the bell is taken out, and by careless persons not replaced. If it is so fastened down that it cannot be removed, the dirt in the box around the mouth of the descending pipe collects and decomposes. It is better to use the forms of traps already described, protecting them with a grating. Masonry or wooden traps may be constructed on the "mid-feather" principle, with partitions extending vertically across the drain and dipping down from the crown into the trap-chamber, between the points of entrance and discharge.

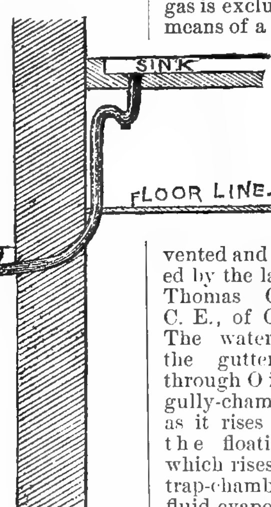
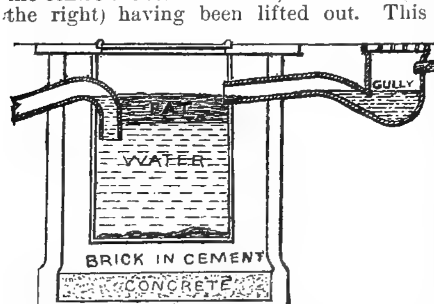

FIG. 3507.—Intercepting Grease-chamber, with Disconnecting Gully-trap.

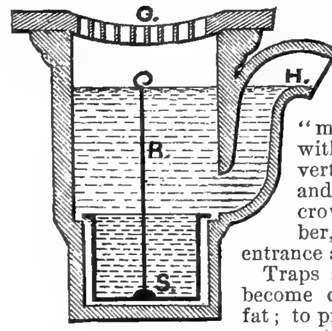

FIG. 3508.—Dean's Yard- or Gully-trap.

Traps and drains are liable to become choked with congealed fat; to prevent this, grease-traps are sometimes employed. A form of grease-trap is shown in Fig. 3507, copied from a paper in "Our Homes," by Mr. William Eassie, an English engineer. To the left may be seen the grease-chamber, closed by a cover, which may be removed in order to skim off the floating fat. This chamber should be ventilated by a pipe or pipes, carried to a safe position away from openings into the house. In the centre is seen a gully-trap for taking surface-water from the yard, and also for disconnecting the sink-waste outside the house. This "disconnection" is, of course, unsuited to the climate of the northern portions of our continent, but in England it is common to disconnect the house-drainage just outside the house.

Fig. 3508, from the same work, shows Dean's yard- or gully-trap, which contains a box, S, for catching any dirt that may drop through the grating G. To the box is attached a rod, R, by which it may be lifted out when it is necessary to empty it. H is the discharge-pipe.

Fig. 3509 represents a street-gully, from which sewer-gas is excluded by means of a trap invented and patented by the late Mr. Thomas Guérin, C. E., of Ottawa. The water from the gutter runs through O into the gully-chamber C; as it rises it lifts the floating V, which rises in the trap-chamber A, and permits the fluid to escape. As the fluid evaporates, or if it leaks away, the plug falls back into its seat. The plug being conical in its lower portion, R (Fig. 3510, which is an enlarged view of the trap only), any backward pressure of gas drives it more firmly into its seat. It is made of wood tipped with brass, and is furnished with a small hook for lifting it out. The

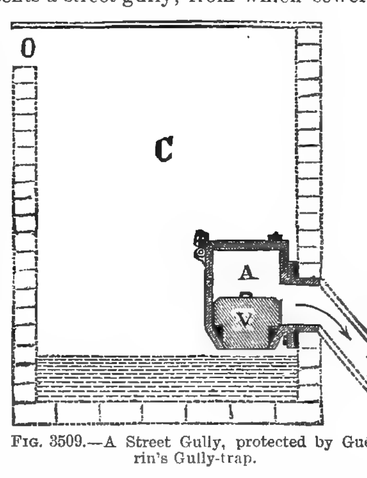

FIG. 3509.—A Street Gully, protected by Guérin's Gully-trap.

trap-chamber is of iron, and fitted with a tight movable cover, X. A trap of this kind will obviate the dangerous, and sometimes disgusting, vapor which we frequently notice from unsealed gullies.

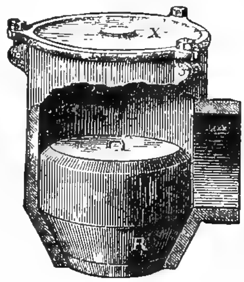

Fig. 3510. — Guérin's Gully-trap. (Larger View.)

Dry Traps.—The principle of dry traps is illustrated in Fig. 3511. Fig. 3512 represents the same style of trap, with a coupling clamp attachment. In these traps the flap is hung without bolt or pin, by being hooked on to two little projecting pieces above the circular opening which it is intended to close. The trap thus formed is inserted into the socket end of any pipe and kept in place by the spigot end of the next pipe above. Its place in a system of sewerage may be tersely described by a certificate given by the writer in 1878, and which he hardly expected would be deemed sufficiently meritorious for publication. Perhaps the patentee valued it as bearing a stamp of dubious honesty on the face of it :

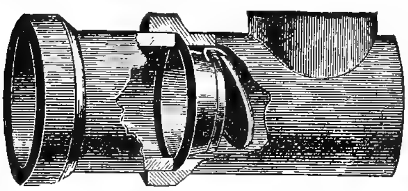

Fig. 3511.—Palmer's Trap.

"The best method of preventing reflux of sewer-gas is, in my opinion, a good water-trap, with sufficient seal, sufficient vent and ventilation, and frequent change of its fluid contents. Where these conditions cannot be obtained, then resort must be had to a *dry trap*, and the very best of these I have ever seen is Palmer's trap."

I am glad to be able to refer now to what escaped me at that time, viz., its power of preventing reflux of back water from sewers into cellars in low-lying districts. One great reason for the preference of water-traps over dry traps is the tendency of the latter to become foul and clogged with deposit, and the liability of their mechanism to become ineffective by reason of rust, dirt, and the interference of solid bodies.

Weeping drains, for draining the subsoil of houses, should not be laid inside the foundation, if it can possibly be avoided. The subsoil of houses, or blocks of houses, can generally be drained by porous tiles laid outside, so as to surround the foundation-walls at a sufficient depth below the level of the cellar floors. When the builder or owner of any particular house cannot accomplish this, he should be careful to provide the trap interposed below the weeping drains with some slight automatic water-supply, so that its contents shall be frequently changed. Sickness arising from want of attention to this particular is common ; the supply of subsoil water ceases, the traps become dry, and sewer-gas passes up into the house. Two examples may be cited. Becoming convinced that there was something wrong with the drainage of a house in which I was attending several members of a family showing symptoms of low fever, I requested a thorough examination to be made. There was no smell of sewer-gas, but on raising the board cover of a trap in the furnace-cellar over which the weeping drains emptied, a blast of air shot upward. Five members of this family were prostrated by typhoid fever. The other instance was in a house where diphtheria persisted in remaining, and recurring ; the weeping drains were found to connect with the sewer (a very foul one), without any traps.

Out-door Closets and Latrines. — That out-door closets and latrines, in connection with the water-carriage system, can be used even in the northern part of this continent, is now established by experience. In the case of careful individuals a hopper-closet, washed while in use by an automatic swirl of water from a valve set below the frost line, may be used ; but when numbers of persons of various classes have to use closets, they cannot be relied upon for care and cleanliness. Latrines should therefore be used to supersede the privy-pit in the densely populated districts in which the water-carriage system is established, unless it is resolved to use the dry system under corporation management. In many places the change from the old system to the new is being gradually made. No new pits are allowed to be dug ; and when any existing one becomes a cause of complaint, it is ordered to be cleaned and disinfected, and filled with fresh earth. These latrines can be controlled by some servant of the corporation, or other person, who shall, from time to time, change their contents and supply them with water. Of the various forms of latrines, the following may be mentioned :

So-called *iron sinks* are manufactured in various cities on this continent, and are being largely introduced. One of them, Mott's Latrine, is shown in Fig. 3513. The hopper, or receptacle, and its corresponding section of drain, are made in one piece, and the several portions of the drain are then connected. The contents are run off periodically by raising a plug at one end of the drain, and the drain and latrines are refilled. When these are situated out-doors, slight artificial heat must be used in winter. These latrines are very moderate in price.

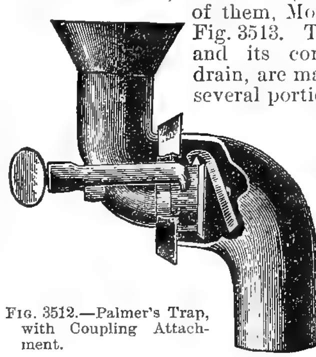

Fig. 3512.—Palmer's Trap, with Coupling Attachment.

The *Liverpool trough-closet* "may be described as consisting of a series of closets communicating with a long trough (*W*), situated beneath and behind the seat, which receives the excreta from each closet in the series. The lower end of the trough communicates with a drain (*D*, Fig. 3514), leading to the sewer by an opening which is closed by a plug (*P*). Behind the back wall of the closet there is a small space to which no one has access but the scavenger, and from which alone the plug can be raised by means of a handle. The scavenger visits the closet daily, empties the trough, washes it out with a hose (*A*) connected with a hydrant, and again charges it with water. As much water is let in as will cover the excreta received during twenty-four hours, and so prevent any smell. The closets are kept clean by the users." *T* represents a trapped overflow from the closet-trough to the drain, to prevent any accident from leakage of the hose-pipe.

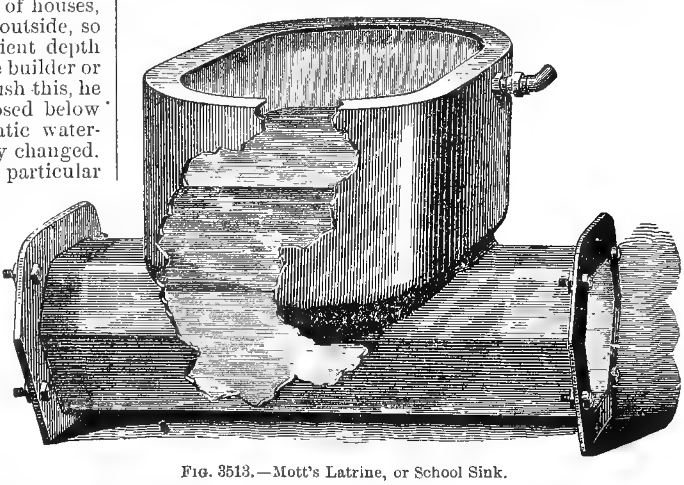

Fig. 3513.—Mott's Latrine, or School Sink.

The Bristol Eject.—This consists of a strongly constructed dip-trap, interposed between the privy-trunk, as the receptacle is termed, and the drain. It thus admits of the ready extraction of foreign matters which may be thrown in; it is not easily broken; and, as it is flushed and kept clean by the servants of the corporation, it is found to answer much better than ordinary water-closets among the poorer classes of large towns.

Other forms of latrines, on the same principle, are thus spoken of in Wilson's "Handbook of Hygiene:" "For barracks, prisons, etc., water-latrines of a much simpler construction than either of the above answer exceedingly well. An open metal trough, roofed in, and with the necessary partitions and doors, receives the excreta, while its anterior upper margin constitutes the seat. In order that the excreta may be constantly covered, the trough should be kept one-third full of water. It should also be well flushed at least twice daily, and the contents allowed to run off into a drain connected with a sewer. A plug, or flap-door, at the lower end of the trough, will be required to prevent the water from draining off at intervals.

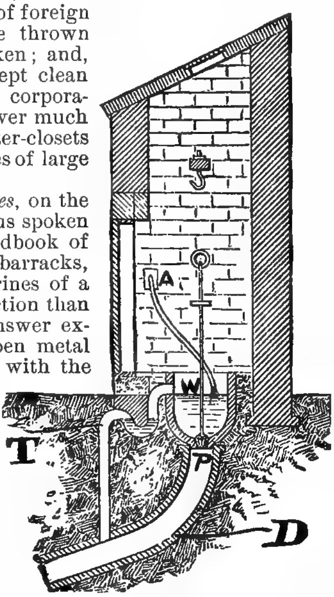

FIG. 3514.—Liverpool Trough-closet.

"There is a further advantage, common to all closets of the trough system, which may here be pointed out. In the event of an epidemic of cholera or enteric fever raging in the crowded courts where these closets are in use, it will be an easy matter to throw disinfectants into the troughs and thus destroy the infectious power of the alvine discharges."

In some latrines water does not stand in the receptacle, but is admitted daily to sweep out the contents with a sudden flush. Those in which fæces are received into the water, the whole being suddenly let off and flushed, are to be preferred.

If a moderate artificial heat were introduced with the use of such latrines a double gain would be secured. The exposure to severe cold is sometimes very injurious. Not to enter deeply into the subject, let us take the case of a school-child just recovered from scarlet fever, the peeling of the skin having been accomplished; exposure of the skin to severe cold may produce fatal disease of the kidneys. If, however, these conveniences cannot be heated, we must place the water appliances deeply, as is done now with our water-pipes, hydrant-services, and drains, always remembering that the open troughs are more exposed to atmospheric changes of temperature. In this regard great care needs to be exercised.

URINALS become offensive through want of proper provision for preventing the incrustation of them with deposits from the urine, and of proper means of frequently cleansing or removing surfaces which collect the droppings. A tray of ashes or sawdust in front of and beneath the urinal will meet this latter requirement, the contents of the tray being frequently changed. The urinal should have in front a narrow projecting lip. For the first mentioned cause of offensiveness it seems necessary to have a flow of water washing the urinal while in use. For this purpose various automatic contrivances have been arranged, such as the opening of a valve-tap, when a person stands upon a platform in front of the urinal.

INTERCEPTING SEWERS may be divided into those which intercept or receive the whole of the contents of other sewers, and those which intercept only a portion of the contents, allowing the rest to flow on. There is nothing peculiar in the construction of the former. They may be used under various circumstances. For example, a city may be so situated that the sewage of the upper district would flow by gravity to the intended outfall, while that of the lower districts would not; in such case the sewage of the upper district would be collected and carried off to the outfall by an intercepting sewer, the sewage of the lower district being pumped either to the intercepting sewer on the higher level, or directly to the outfall. Or the configuration of the place may be such that the natural drainage of the streets has a very long fall, while there may be a water-course lying at a comparatively short distance to one side; in this case a great saving in the size of the sewers may be effected by intercepting and beginning anew below the intercepting sewer. Or the city may be built on knolls, so that an intercepting sewer becomes a necessity, unless Shone's system (see below) is employed.

Sometimes it is desirable to collect only the more concentrated portion of the sewage, and allow the less impure to flow on, either because the former has to be utilized or pumped, or in order to save expense in the size of the intercepting sewer. How this object may be accomplished is shown in Fig. 3515. The intercepting sewer is seen below the divided invert, *C*, *E*, of the sewer, the concentrated sewage of which is to be intercepted. The ordinary fair-weather flow, and the first impure flush of a rainfall, will drop through the opening *B*,

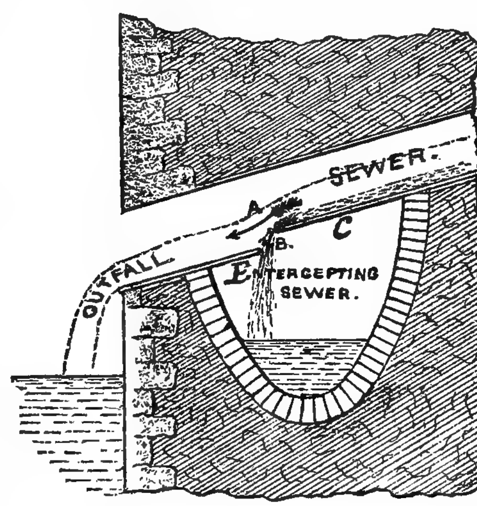

FIG. 3515.—Intercepting Sewer, with Overflow.

while a heavy flow or flood of water will shoot over, as represented by the dotted line *A* in the diagram.

Another example of intercepting sewer is shown in Fig. 3516. The description is taken from an "Account of the Trunk-sewer of Buffalo," by Col. George L. Waring, Jr.: "The connection of the trunk-sewer with the city sewers is shown in Fig. [3516], representing the Porter Avenue interception. The dry-weather flow of the sewer is delivered at an angle of forty-five degrees with the course of the trunk sewer, through a cast-iron pipe two feet in diameter. The bottom of this pipe is one foot above the bottom of the sewer, and its top is one foot below the middle of the sewer.

"For dry weather and light rains this would suffice. In order to secure the introduction of as much as possible of the discharge of the city sewers during heavy storms, it was arranged that its flow should be somewhat stilled in a well over the mouth of the inlet-pipe, to allow the escape of the large volume of air sometimes involved in the rapid current of steep sewers during storms. This is so done as to bring the full head of the intercepted sewer to bear on the inlet.

"So much of the flow as cannot gain access to the

trunk-sewer through the lower inlet, passes on over the vertical well and runs into it through a three-foot opening in its crown. Should the sewer be so full that the entire flow of the intercepted sewer cannot gain admission, the surplus passes on to the canal."

Tidal variations cause much difficulty in connection with outfall sewers; by the ebb and flow of the sewage-laden tide a serious and wide-spread nuisance is often created. And in this connection it should be borne in mind that sewage oxidizes more slowly in

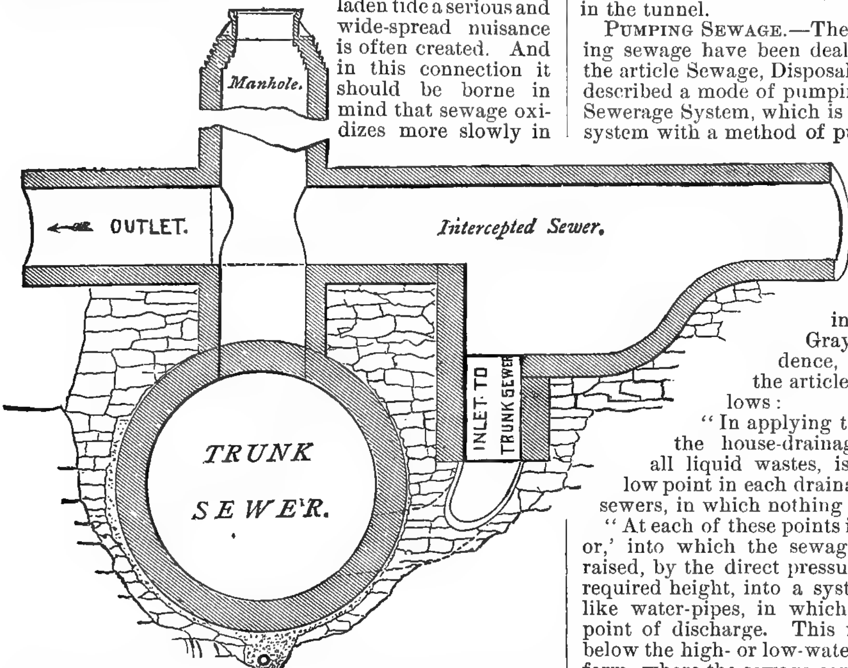

Fig. 3516.—Intercepting Sewer, Porter Avenue, Buffalo, with Overflow.

sea-water than in fresh water. If the sewer discharges continuously on the shore at or near high-water mark, the nuisance is intensified; if it discharges below low-water mark, the rising tide causes a backing up of the sewage and deposit of its solid portions, with all the evils incident to such a condition. It will also, by rising in the sewer, force backward the gases therein contained. To prevent this, flap-valves are often placed on the mouths of such sewers. It is more desirable to make ample vents for discharging the sewer-gases, as before described when speaking of the ventilation of sewers.

Fig. 3517, copied from "Suggestions as to Plans for Main Sewerage," by Robert Rawlinson, C.B., C.E., of the Local Government Board of Great Britain, is a "suggestion" for an outfall adapted to tidal variations. Its

pumping-station, where it is raised to a sufficient height to enable it to flow through a tunnel, over a mile long, beneath Dorchester Bay, to Squantum, and thence through a flume, for another mile, to Moon Island; here it is held in reservoirs and periodically discharged into the outgoing tide. At the pumping-station such straining and subsidence are effected as may be necessary to obviate deposit in the tunnel.

Pumping Sewage.—The ordinary methods of pumping sewage have been dealt with, as far as needs be, in the article Sewage, Disposal of; there now remains to be described a mode of pumping, called Shone's Pneumatic Sewerage System, which is a combination of the separate system with a method of pumping sewage by the direct action of compressed air, the reverse of that employed in the Liernur and Berlier systems. It is the invention of Mr. Isaac Shone, a mining and civil engineer of Wrexham, Wales. It is well described in the report of Mr. Samuel Gray, Civil Engineer, of Providence, R. I. (already referred to in the article on Sewage Disposal), as follows:

"In applying this system to a city or town, the house-drainage, comprising excreta and all liquid wastes, is conducted by gravity to a low point in each drainage district, through ordinary sewers, in which nothing else is permitted to flow.

"At each of these points is situated a 'pneumatic ejector,' into which the sewage flows, and by which it is raised, by the direct pressure of compressed air, to any required height, into a system of cast-iron pipes jointed like water-pipes, in which the sewage is forced to the point of discharge. This may be at the sea-shore, far below the high- or low-water level, or may be at a sewage farm, where the sewage can be applied to the land. Another arrangement is to deliver the sewage from the ejectors into an upper tier of gravity-sewers leading to the outfall. The choice between these two methods depends upon the topography of the locality.

"The air, which forms the motive power of all the ejectors, is compressed at some convenient place by a compressor operated by steam or water power. Thence the compressed air is supplied to the ejectors through small iron pipes laid through the streets.

"The system is confined to the removal of house-

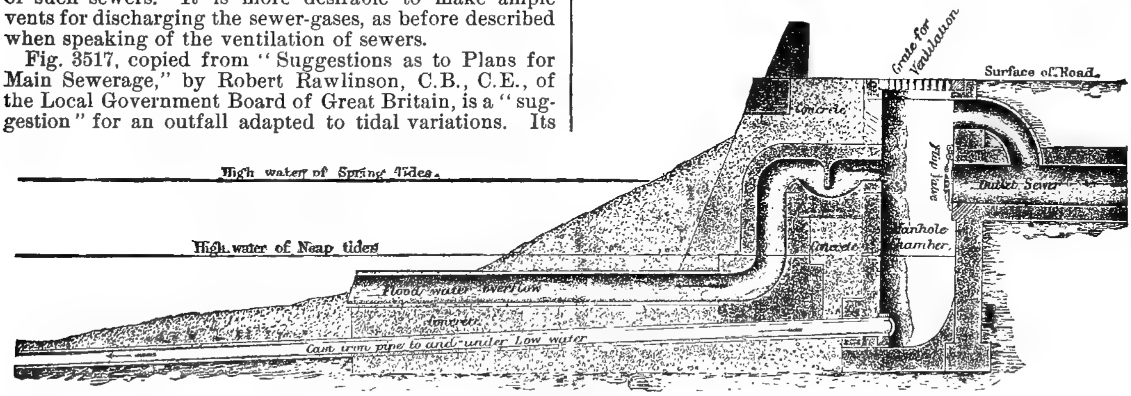

Fig. 3517.

construction is explained by descriptions on the cut itself. It will be noticed that the pipe leading "to and under low-water" is of smaller size and steeper gradient than either the "Outlet Sewer" or "Flood-water Overflow;" the tendency of this would be to prevent deposit.

In Boston the difficulty has been met by building a main sewer (with elaborate overflow and other appliances) which conducts the sewage over three miles to a

sewage, both to prevent its dilution and to render more uniform the volume of liquid to be raised by the ejectors; it being evident that, should storm-water and subsoil drainage be admitted, the ejectors would either be unable at times to perform the work required of them, or would need to be so large that they would not work economically under ordinary conditions. Storm-water and subsoil drainage are therefore expected to be con-

veyed in a distinct system of sewers." . . . "The sewage is discharged from the gravity-sewers into a receiving chamber, from which it passes into a separating chamber, where all floating substances are arrested, and thence into the ejector. Sometimes the sewage passes directly from the gravity-sewers into the ejector." . . . "The action of the ejector is seen in Figs. [3518] and [3519]. Fig. [3518] shows the ejector while it is filling. At the top of the ejector is an automatic-valve apparatus, controlled by a weighted lever. A rod connected with one end of this lever passes through a stuffing-box, and into the interior of the ejector. On this rod is a reversed cup or 'bell,' and connected with its lower end is a weight or 'cup.' While the ejector is filling, the valve marked 2 is held to its seat by the pressure from the rising main, and the valve marked 1 is lifted by the pressure of the inflowing sewage. The air within the ejector passes out through an exhaust-port and pipe to the man-hole or sewer. When the ejector is full, the 'bell' is affected by the buoyancy of the water, and the weighted lever falls, closing the exhaust-port; and immediately afterward opening the inlet-port, admitting compressed air to the interior of the ejector. This action upon the surface of the sewage causes the valve 1, Fig. [3519], to close, and the valve 2 to open and permit the passage of the sewage to the pressure-main in the street at a higher level, to which it is raised by the force of the compressed air. When the sewage has fallen to the bottom of the 'cup' suspended from the valve mechanism, its buoyancy has been withdrawn and the 'cup' falls and reverses the valves, closing the inlet-port and immediately afterward opening the exhaust-port through which the compressed air within the ejector escapes by a pipe leading to the man-hole or to the sewer. The atmospheric pressure being restored within the ejector, the valve 2 closes, and it begins to refill with sewage.

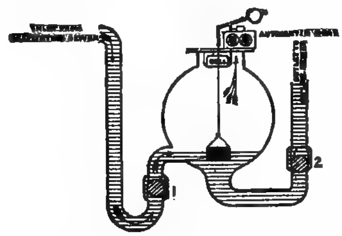
FIG. 3518.—Shone's Ejector, Filling.

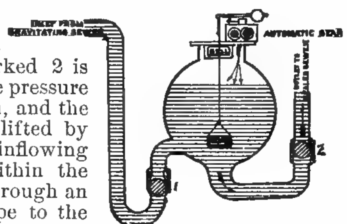
FIG. 3519.—Shone's Ejector, Discharging.

"From this description it will be seen that the Shone system is essentially a method of pumping sewage in detail by means of small pneumatic pumping engines, situated in different parts of the city, all of which are operated by power generated at a single station. The system may be applied to the entire sewerage of a city, or may be confined to special districts, according to circumstances.

"The Shone system is particularly valuable in the sewerage of towns where fall sufficient to produce a proper velocity of flow cannot be obtained, and where it is impracticable to convey the sewage to one general pumping station, since in this system it is not necessary to follow the general topography; but the sewers may be given such grades as may best promote the rapid discharge of the sewage. An ejector may be placed wherever these grades cause the depth of the sewer to be excessive, and the sewage may be raised to a height from which it may flow to the outfall, either under pressure or by gravity. The cost of an equal number of small steam-pumps, with their appurtenances, to do the work done by the ejectors, would be very great."

RELATIVE VALUE OF THE SEPARATE AND COMBINED SYSTEMS.—Of the separate and combined systems of sewerage, the distinctive features and some of the relative merits have, of necessity, been described and discussed under the various details of Sewerage and Sewage Disposal. A brief comparison will therefore be all that is necessary here.

In behalf of the separate system it may be urged:

From a sanitary standpoint, the smooth glazed pipes are less liable to deposit and to acquire a slimy lining.

They can be more fully and readily flushed at will and periodically.

Their smaller size leaves less surface for the exhalation of vapor, less space for its collection, and greater facility for its change by removal.

From an economical standpoint, its cost is very much less, say from $0.75 to $2.00 per foot, as compared with that of the combined system, say from $5.00 to $10.00 per foot, which figures are given by Messrs. Staley and Pierson.

The advocates of the separate system state that street and surface filth should be swept up and removed by some dry method.

That even when the combined system is used for the safe conduct of surface water the sewers are insufficient in time of unusual flood, and flooding of cellars takes place.

By those who hold that the combined system may, under certain circumstances, be the most advisable, it is represented:

That inasmuch as it is well known that excreta only form a small percentage of the filth of sewage, and that street and surface filth form a large percentage, it is necessary to provide for the removal of the latter, and water-carriage is the cheapest and best method of removal.

That in places where the natural drainage fall is lengthy, the volume of water will become so great that subsurface conduits become necessary; and it is only once in years that these volumes become so excessive that flooding of cellars takes place, the fall in the sewer and over the surface generally provided being sufficient to prevent flooding. That flooding is more likely to take place by overflow from the surface, and hence is more liable to occur with the separate system.

That some cities are so flat that surface water would stand in ponds.

That the cost is increased by providing two systems, one for rain- and storm-water, and another for household sewage.

That obstructions in the small pipes of the separate system necessitate frequent excavation down to the sewer.

That in deep cuttings the pipes are liable to be crushed (unless made of iron) and obstruction thus take place.

That two systems of sewer-pipes in the same street are liable to give rise to confusion in making connections and repairs.

There is much force in the arguments for both systems, and perhaps we should not look upon them as opposed arguments on behalf of rival systems, so much as points to be considered in connection with the sewerage of any particular place.

There can be no hesitation in saying that in a place where the surface water can be left to flow off over the surface without flooding houses or impeding traffic, and where it will not cause pollution, the separate system is the best.

Nor can there be much hesitation in saying that in other cases, if we can compass the cost of sewage and storm-water conduits separately, it had better be done.

But it is evident that in each community it is necessary to make a study of all attending circumstances, and we cannot lay down a dogmatic decision to apply to all; we must be guided by principles as applied to the particular circumstances.

There may, too, be a happy medium, as there is in most things; the mode of intercepting only the more concentrated portion of the surface water, that which first flows in, has already been referred to. Another plan, that might with advantage be adopted in places where the surface water is liable to form streams too large to flow over ground all the way to the outfall, would be to admit it in the higher districts into the (combined) sewers, and to exclude from them that in the lower

districts. The advantages of this would be that the upper parts would receive the flushing which they more especially need, the size of the sewer would not increase below to the great extent that it now does, and the volume of surface water from the lower districts only would not be so great.

THE PRESERVATION OF DRAINAGE AND SEWERAGE PLANS is a matter to which I would refer as one of very great importance. Often they are lost or do not pass into the possession of those most interested, the owners of the properties concerned; and a vast amount of time is lost, property destroyed, and mistakes committed, in delving and searching for hidden drains. When our health organizations are firmly established in the relations they should occupy in regard to the sanitary construction of houses, copies of all such plans and specifications should be obtainable from them. When they are not so, and perhaps in any case, these plans should be preserved in the registry offices along with the title-deeds.

In conclusion, I desire to express my thanks to the gentlemen whose names and work have been mentioned in this article, and to any others whose names have been overlooked, but from whom, as contributors to the general fund of information on this subject, I have derived assistance. *Wm. Oldright.*

SEWER-AIR (Sewer-gas). DEFINITION. — Sewer-air, as the name implies, is the air usually found in sewers. It is composed of atmospheric air containing certain gases, vapors, and micro-organisms resulting from the decomposition of sewage and excrementitious matters found therein.

In this article the definition will be extended to include the air of house drain-pipes, privy-vaults, cesspools, and other imperfectly ventilated places containing decomposing animal and vegetable matters.

The term "sewer-gas" is frequently used as synonymous with sewer-air, but it is objectionable, from the fact that it seems to imply that sewers contain a specific gas having a definite chemical composition. Such is not the fact; on the contrary, sewer-air is a mixture of air with other gases and vapors in ever-varying proportions.

COMPOSITION.—In order to understand the composition of sewer-air we must call to mind the composition of sewage, and how the air is contaminated by it. Sewage of cities and large towns consists of water flowing slowly through an underground conduit, and holding, partly in solution and partly in suspension, the excreta of men and animals, refuse from kitchens, grease, soap, the drainage from slaughter-houses, stables, factories, laundries, streets, etc. It is therefore a complex mixture of organic and mineral matters, very prone to putrefactive decomposition. This decomposition is brought about by the agency of the usual putrefactive bacteria, and with the development of carbonic dioxide (CO_2), marsh-gas (CH_4), nitrogen, ammonia, and sulphuretted hydrogen (H_2S).

Letheby found that sewage-water containing 128.8 grains of organic matter per gallon, and excluded from air, evolved, for nine weeks, 1.2 cubic inch of gas per hour, or 28.8 cubic inches per day. The analysis of this gas gave, in 100 parts, by volume:

Marsh-gas	78.83 parts.
Carbon dioxide	15.90 "
Nitrogen	10.19 "
Sulphuretted hydrogen	0.08 "

Similar experiments with sewer-mud in the Seine, by Durand-Claye, gave a gas of the following composition:

Marsh-gas	72.88 per cent.
Carbon dioxide	13.30 " "
Nitrogen	4.58 " "
Carbon monoxide	2.54 " "
Sulphuretted hydrogen	6.70 " "

Such mixtures are never found in an ordinary sewer, as the gases are always mixed to a greater or less extent with air. The quantity of these gases to be found in the air of a sewer will depend upon the composition and the velocity of the movement of the sewage, as well as upon the ventilation of the sewer.

Dr. Letheby gives the following as the average percentage composition of the air of London sewers:

Oxygen	19.51
Nitrogen	79.96
Carbon dioxide	0.53
Marsh-gas	traces
Ammonia	traces
Sulphuretted hydrogen	traces

Professor W. R. Nichols, of Boston, analyzed the air of a badly ventilated sewer in that city, with the following maximum and minimum percentages:

	Maximum.	Minimum.
Oxygen	20.90	20.48
Nitrogen	79.26	78.89
Carbon dioxide	0.50	0.40
Sulphuretted hydrogen	trace	trace

In extreme cases the oxygen has been found as low as 13.79 per cent., the carbon dioxide as high as 3.4, and sulphuretted hydrogen as high as 2.99 per cent. Besides the gases here mentioned, sewer-air always contains bacteria and volatile organic matters, sometimes in large amount. The exact nature of these organic matters is not well understood. Some of them seem to belong to the class of bodies known as compound ammonias, or amines. When sewer-air is shaken up with a dilute solution of potassium permanganate, the organic matter undergoes oxidation at the expense of the oxygen in this salt.

We may form an idea of the amount of organic matter present by the amount of a standard permanganate solution decolorized by a measured volume of the air. Dr. Angus Smith found that the air of a cesspool destroyed two thousand eight hundred and forty times as much permanganate as the same volume of pure air. The air of a house into which sewer-air had penetrated destroyed twenty times as much permanganate solution as the same volume of pure air. These organic matters are probably much more deleterious constituents than those shown by the chemical analyses above quoted. These gases seem to possess considerable diffusive power, and will pass easily through walls and porous earthenware, or brick sewers. In this way these gases frequently find their way into the cellars of houses, especially in the vicinity of a broken sewer or improperly constructed cesspool. Fungi readily grow in such air, and articles of food, such as meat or milk, soon become tainted and decompose when exposed to it. Experience has shown that stagnant sewage gives off more gas, and is more dangerous, than that which is kept in motion. Sewer-drains which have a steep grade are, therefore, to be preferred to those having a slight grade. Where sewers are frequently flushed with water, and where there is no chance for stagnation, with a reasonably good ventilation, the danger from sewer-air is reduced to a minimum.

There are very strong reasons for believing that the specific poisons, or germs, of a number of the contagious diseases may be transmitted by sewer-air. That dysentery, diarrhœa, and periodic fevers are frequently produced by sewer-emanations cannot be doubted. It is also believed that the poisons of typhoid fever, of cholera, and of yellow fever, have been transmitted from house to house by the medium of the sewers. Indeed, the evidence of such transmission amounts almost to a positive proof.

PHYSIOLOGICAL EFFECTS OF SEWER-AIR.—The effects of breathing sewer-air depend upon its composition and upon the degree of dilution. Poisoning by this gas, or mixture of gases, may be acute and rapidly fatal, or chronic, only manifesting itself after weeks or months of exposure. Acute poisoning from breathing sewer-air, or the air of cesspools, privy-vaults, etc., occasionally leads to fatal results. These effects may usually be traced to one of two causes: 1. The air may be deoxidized, or deficient in oxygen, and contain excess of carbon dioxide. 2. It may contain a poisonous quantity of sulphuretted hydrogen (H_2S).

According to Thénard, asphyxia of persons by breathing sewer-air is often due to breathing an air containing a deficient supply of oxygen, rather than an excess of

carbon dioxide. Experiment has repeatedly shown that an animal can endure for hours a greater proportion of carbon dioxide than is ever found in ordinary sewer-air, provided that the proportion of oxygen is kept up to the normal amount, or is in excess of the normal. The poisonous properties of carbon dioxide are very slight when the oxygen of the air is increased above the normal proportion. Thus, an animal may live for hours in an atmosphere composed of forty per cent. of oxygen, twenty per cent. of carbon dioxide, and forty per cent. of nitrogen. An addition of five per cent. of carbon dioxide to normal air may be endured for some time without fatal poisoning. As sewer-air seldom contains more than four per cent., it is evident that unless the oxygen be reduced below the normal, the mixture could not prove rapidly fatal from carbon-dioxide poisoning. A case of asphyxia from breathing sewer-air, then, is oftener due to a deficiency of oxygen than to an accumulation of carbon dioxide; or, perhaps, to the combined effect of this with an excess of carbon dioxide. In such cases resuscitation is likely to prove successful, if pure air can be supplied in time.

In certain cases sewer-air may contain enough sulphuretted hydrogen (H_2S) to become poisonous. A number of cases of fatal poisoning by sewer-air containing sulphuretted hydrogen are on record. Woodman and Tidy[1] mention twelve cases of sewer-gas poisoning. They seem to attribute the poisoning to H_2S in most, if not all, of these cases. It must be admitted that it is only in exceptional cases that this gas accumulates in sewers in sufficient quantity to give rise to acute poisoning.

A discharge of a considerable quantity of mineral acid into a collection of sewage-matter containing an abundance of sulphides may cause an evolution of H_2S, which, in a poorly ventilated and flushed sewer, may accumulate in fatal quantity. A liquid charged with sulphuretted hydrogen or ammonium sulphydrate, like gas-liquor, may be discharged into a sewer so as to temporarily poison the air. By far the largest number of these cases of acute poisoning occur to workmen engaged in handling night-soil, the contents of privy-vaults and cesspools, or the mud of sewers. In such cases the pent-up gases may escape in poisonous quantities, and overcome the workmen before it has had time to diffuse itself. Sulphuretted hydrogen is a deadly poison, even when mixed with large quantities of air.

The results of experiments upon animals show that:[2]

1 part of H_2S in 1,500 of air killed	small birds	Parent du Chatelet.
1 " " " 290 " " "	rabbits	
1 " " " 250 " " "	horses	
1 " " " 1,800 " " "	birds	Dr. Barker.
1 " " " 210 " " "	dogs	
1 " " " 2,000 " " "	birds	Dr. Letheby.
1 " " " 200 " " "	dogs	

Dr. Letheby considers that one per cent. of the gas in air would destroy human life. As $\frac{1}{100}$ per cent. (1 part in 10,000 of air) can be detected by the odor of rotten eggs which it imparts, there can be little danger of being acutely poisoned by it unawares.

It is more than probable that the fatal effects, above referred to, are as largely due to deoxygenated air as to the poisonous action of the sulphuretted hydrogen, or of the ammonium sulphide.

TREATMENT OF ACUTE POISONING BY SEWER-AIR.—The treatment of this form of poisoning may conveniently be divided into preventive and remedial.

The prevention of acute poisoning by the air of sewers, cesspools, etc., is very simple. In sewers thorough flushing and ventilation is all that is needed. In cesspools and vaults it is important to stir their contents before emptying, in order to allow the greater part of the gas to escape. If the generation of hydrogen sulphide is rapid, it may be necessary to throw down a little chloride of lime, a day or two before going into the vault, or to generate chlorine in the vault by means of chloride of lime and dilute acid. The test of lowering a candle into such places is not always a safe test to depend upon. The remedial treatment of asphyxia from sewer- or cesspool-air consists in the admission of fresh air, and the use of cold affusions. Warm brandy or whiskey and water may be given freely, to sustain the heart.

Dr. Eskbridge has used, with success, intravenous injections of aqua ammoniæ fortior in a case of acute poisoning. He proposes to use this solution, diluted with two parts of water, at a temperature of 110° F.

Commonly, the simple removal of the person into pure air, if done without delay, is sufficient to restore him. Woodman and Tidy recommend the breathing of air containing a trace of chlorine, formed by putting chloride of lime in a bottle. The object of this treatment is to decompose the hydrogen sulphide that may be in the residual air of the lungs, or, possibly, in the blood.

SYMPTOMS AND POST-MORTEM APPEARANCES.—The symptoms of acute poisoning by sewer-air, the air of cesspools, or the gases evolved by night-soil, are usually those of asphyxia, or of poisoning by hydrogen sulphide. The surroundings of the person at the time of the accident can usually be determined, and thus the cause of the symptoms, or death, inferred. The first effect will probably be nausea, faintness, or dizziness; cold, clammy skin; frequent pulse, and irregular or jerky respiration.

Later, or if the sulphuretted hydrogen be more abundant, the person loses the power of motion, and becomes insensible. His lips become livid, and a bloody, frothy mucus may exude from the mouth or nose. The pulse becomes weak, rapid, and irregular. The respirations now become rapid, laborious, and irregular. The voluntary muscles are relaxed, with occasional twitchings, or even tetanic convulsions. Death may occur suddenly, or the patient may slowly regain consciousness on exposure to pure air.

The post-mortem appearances are usually those observed after poisoning by hydrogen sulphide. The blood will everywhere be found to be of a very dark color, sometimes almost black, and fluid. The right side of the heart is usually found filled with blood. The body emits an offensive fecal odor, and rapidly undergoes putrefaction. When the cause of death is sulphuretted hydrogen, the mucous membrane of the bronchial tubes is smeared with a dirty-brown mucus, easily rubbed off. This appearance is very characteristic, and may serve to distinguish between suffocation by deoxygenated air and sulphuretted-hydrogen poisoning.

CHRONIC POISONING BY SEWER-AIR, AND THE DISEASES PRODUCED BY IT.—This is a subject upon which a great deal of attention has been spent, without entirely satisfactory results. Opinions differ as to the effects of sewer-air upon the human economy, when breathed for a considerable time in a highly diluted condition. While some physicians believe that it is not deleterious to health under these conditions, others claim that it is a cause of many cases of serious illness, and a frequent carrier of such diseases as typhoid fever, dysentery, cholera, yellow fever, diphtheria, scarlet fever, measles, etc. While it is not easy to obtain reliable data upon this point, the weight of evidence, as well as reason, seems to declare that there is some connection between sewer-emanations and some of the diseases mentioned. It would carry us too far for the limits of this article to discuss at length the evidence that must lead us to this conclusion.

It is certain that there are well-established observations, which seem to prove that sewer-air, even when largely diluted, produces a very deleterious effect upon the health of persons who breathe it for a considerable time. The teachings of writers on toxicology, the clinical experience of hundreds of physicians in our large cities, the experience of sanitarians and of sanitary engineers, all lend weight to this opinion. It is equally certain that these effects cannot be due alone to the gases which have been described as entering into its chemical composition.

Mixtures of air with carbon dioxide, marsh-gas, sulphuretted hydrogen, and ammonium sulphydrate, when prepared in the laboratory, in the arts, or in metallurgical operations, have never been known to produce typhoid fever, dysentery, malaria, or any other of these specific

Sewer-Air.

diseases. Indeed these gases, with the exception of H_2S, are known to be harmless when highly diluted. Sulphuretted hydrogen has lately been recommended and used by inhalation in the treatment of phthisis. The author has so used it, with no apparent ill effect.

Some other cause for the well-known effects of sewer-air must be found than is revealed by the analyses above quoted. This must be in the organic matters or micro-organisms that have been described as present in sewer-air. The air of sewers has been found to contain large quantities of bacteria. This may be easily shown by exposing in a sewer a glass slide moistened with glycerine, and then submitting the slide to microscopical examination.

Professor Frankland[3] has shown that few solid or liquid particles are evolved from sewage unless it be agitated. He found that the ordinary flow of the sewer-water did not scatter any particles into the air; but when it began to ferment and evolve gases, the bursting of these bubbles sent small portions of the liquid into the air. From this fact he argues that sewage pollutes the air with dangerous germs only when it is giving off bubbles of gas. If we take proper measures to carry off the sewage before fermentation takes place, the danger will be reduced to a minimum, or entirely obliterated. If, as above stated, the putrefactive bacteria are thus disseminated through sewer-air, there is no known reason why pathogenic microbes, when present, should not be scattered in the same way.

A case in which sewers probably played a part in the spread of cholera, is given by Dr. Parkes, in his report to the officer of the Privy Council on the cholera in Southampton, in 1866. There is good evidence that the contagious principles of yellow fever and typhoid fever have been disseminated by sewer-air.

In the city of Brooklyn, N. Y., in 1885, there were a large number of cases of typhoid fever in two pretty well-defined localities, both situated on high ground. After a thorough investigation of the cause of the localization of the cases, the conclusion was reached that the sewers were infected by the discharges of a few imported cases; that the poison was disseminated by the sewer-air tending always toward high levels, and gained an entrance into houses in the immediate vicinity through defects in the plumbing. In a very large number of the houses where cases occurred, such defects were actually found on inspection.

Upon this subject Dr. John Simon, Chief Medical Officer to the Privy Council of Great Britain, in his essay on "Filth Diseases," while speaking of morbific ferments, or contagia, says: "The ferments, so far as we know them, show no power of active diffusion in dry air; but, as moisture is their normal medium, currents of humid air (as from sewers and drains) can doubtless lift them in their full effectiveness, and if into houses or confined exterior spaces, then with their chief chances of remaining effective."

Dr. Parkes[4] says: "The air of sewers passing into houses aggravates most decidedly the severity of all exanthemata—erysipelas, hospital gangrene, and puerperal fever (Rigby); and it has probably an injurious effect upon all diseases." "Two special diseases have been supposed to arise from the air of sewers and fecal emanations, viz., *diarrhœa* and *typhoid* (enteric) *fever*." That typhoid fever may, and frequently does, arise from sewer-emanations is a doctrine certainly well supported by facts. The writer's experience has furnished examples of this fever that were apparently contracted from sewer-air. There are several cases on record where typhoid fever has constantly recurred in houses exposed to sewer-emanations, and in which proper attention to sewer-defects has completely prevented further outbreaks.

Water has been known to become contaminated by sewer-gases, and afterward to produce typhoid fever in those who drank it. Dr. F. de Chaumont[5] cites a case where a cistern was thus poisoned by sewer-air passing into it from the sewer through the overflow-pipe. An analysis of this water showed it to contain a considerable excess of "albuminoid ammonia," derived from the absorbed gases. A similar case is recorded by Dr. Robert King, in the *Medical Times and Gazette* for August 2, 1879. These, and other similar cases, add an interest to the question of overflow-pipes to wells and cisterns, and of the efficacy of water-traps, not usually appreciated.

Mr. William Budd cites instances in which those members of a particular household, who used one closet into which the dejecta of a typhoid patient were thrown, contracted the disease, while other members of the same household, who were in close personal contact with the sick person, escaped.

From what is here said, it will be understood that the results of breathing sewer-air are not always the same. The effects will depend upon the quality much more than upon the quantity of the air breathed. A small amount, at one time, may cause a fatal contagious malady, and at another time a much larger amount may produce only a slight malaise. A small quantity laden with the germs of a specific disease is more dangerous than a large quantity of gas from an uninfected sewer.

Symptoms of Chronic Sewer-Air Poisoning.—As already remarked, the symptoms of sewer-air poisoning are usually insidious in their development, and by no means always constant. I am disposed to believe that the effects may even remain unnoticed for months, as long as the sewer is not infected with harmful germs, and may develop with certainty whenever such infection does occur.

In adults the symptoms, when no specific disease-germs are at work, are malaise, headache, loss of appetite, with even dyspeptic symptoms, drowsiness, and slight feverishness. There is a marked tendency to anæmia and general debility. These symptoms are frequently grouped under the name of "malaria." In children, to these symptoms may be added a smooth or glazed, broad, flabby tongue, with a marked tendency to digestive trouble, as vomiting, diarrhœa, dysentery, and attacks of gastric catarrh and catarrhal tonsillitis.

The tendency of sewer-air poisoning, then, is to derange the organs of primary assimilation, rather than the lungs; as, for example, gastric catarrh, duodenitis, hepatitis, spleuitis, diarrhœa, enteritis, and colitis. Besides these effects, the debilitating influences of the polluted air render the persons so effected an easy prey to any intercurrent malady.

In times of epidemic diseases these are apt to assume a severe or malignant type. There is less tendency to periodicity, and more variability in sewer-air poisoning than in marsh-miasm. The effects seem to depend largely upon the bodily vigor and activity, at the time of exposure, and are therefore greater in night exposure than during active working hours. Hence workmen engaged in ventilated sewers and vaults seldom suffer any particular harm. Numerous inquiries upon this subject have been made, and, although there has been some difference of opinion, the weight of evidence would seem to indicate that sewer-workmen suffer no more from disease than do other men, aside from a few accidental cases of asphyxia. Those who suffer most from sewer-gas poisoning, or sewer-malaria, are women and children who spend most of their time in the house, especially in poorly ventilated apartments. As might be expected, an exposure to sewer-air during sleep is more dangerous than during waking hours, and during a period of active exercise.

While we admit the injurious nature of air contaminated with sewer-air, we must admit that we occasionally meet with cases where persons have lived in houses for years, where traps were unknown, and have suffered from no apparent bad effects. These facts have led some sanitarians to deny the relation of sewer-air to any form of disease. It will not be claimed that the specific germs of disease are always present in any given sewer, especially if it is well ventilated, and if the sewage is constantly in motion. The air of a badly ventilated and stagnant sewer is always to be regarded as more dangerous than that of one where these conditions do not prevail. It has repeatedly been shown that the conditions under which the various microzymes grow, have a great influence upon their virulence in producing disease. It is

quite possible that the ordinary putrefactive bacteria, when germinating in pent-up sewage, may be the cause of the catarrhal sore throats and diarrhœas produced by sewer-air. The virulence of many of the microzymes of the specific diseases, when present in sewers, is increased by germination in closely confined and stagnant sewage. It will be admitted that these disease-germs are not always present in sewers, and under favorable conditions, such as rapid flow and free ventilation, would do no damage when they were present. The importance of securing these favorable conditions in sewers is therefore very apparent.

Treatment.—The treatment of chronic sewer-gas poisoning is partially remedial and partially preventive. In the former, fresh air is of first importance. Pure outdoor air acts as a tonic, and, at the same time, a diluent and disinfectant of the sewer-air. As the tendency of sewer-air, aside from the specific disease-germs, is to produce a lowered vitality and anæmia, quinine, arsenic, salicin, iron, and the mineral acids are indicated. A change of location is often of the greatest benefit. It should be remembered that the effects of sewer-air are frequently seen only in their aggravation of other maladies. Thus, a simple sore throat may, under its influence, assume a very serious and aggravated form. A simple gastro-intestinal catarrh, in children exposed to sewer-air, is often found to be most intractable, until a change of location is secured. The author has seen cases of summer diarrhœa very greatly benefited, and even cured, by a removal for the distance of a few blocks in the city. The effects of a removal to the country are too well known to demand discussion. Many of the cases of infantile cholera are undoubtedly due to the combined effect of a polluted air and high temperature. Fresh air is curative in a large number of these cases.

The effect is the same whether the fermenting sewage is contained in sewers or has soaked into the ground about the house. Both may pollute the air with the same gases, and may produce like effects. When furnace-fires are used in the house, the gases from a sewage-soaked soil may be drawn into the cellar and thence into the rooms above, giving rise to all the injurious effects of sewer-air.

The prevention of sewer-air poisoning is of more importance than is its treatment. The principal requisites for a system of sewers are, free ventilation of all drain- or waste-pipes, and sufficient grade or inclination in outlet-pipes to secure a somewhat rapid current of the sewage. To secure thorough ventilation of the pipes in the house, it is now customary and proper to carry a ventilating pipe, from the sewer side of all traps, to a larger pipe leading to and above the roof of the house; also, to carry a pipe from the house side of the trap, between the house- and street-main, to the open air. This last pipe allows the air to enter the house-system, whence it finds its way, in a constant current, through the pipes and out of the ventilating pipe above the roof. By this arrangement there can be no stagnant air in the pipes of the house, and they are constantly purified by a current of out-door air. When this is secured, and there is no leakage in the pipes, we need fear no trouble from sewer-air.

Detection of Sewer-Air.—The detection of sewer-air is not always an easy matter. The chemical tests depend upon the detection of sulphuretted hydrogen (H_2S) or ammonium sulphydrate. If a piece of filter-paper be dipped in a solution of lead acetate, and be exposed to an atmosphere containing either of these substances, it turns dark-brown, and finally black. A paper dipped in a solution of nitro-prusside of sodium assumes a crimson, and turmeric paper a brown color with ammonium sulphydrate. White-lead paint is darkened by both the above compounds, while zinc white is not changed in color.

The peculiar odor of H_2S may be easily detected, when the proportion reaches 1 part in 10,000 of air. On closing a room tightly for some hours, and then going into it from the open air, a musty or oppressive odor is detected when sewer-air or emanations from decomposing animal matters have found their way into it. If any circumstance should lead to the suspicion that sewer-gas is entering a room or house, it would be best to test the drain-pipes by the "smoke test" or the "oil-of-peppermint test."

A suspected joint in a sewer- or drain-pipe may be tested by wrapping it with a single layer of white muslin moistened with a solution of acetate of lead. As the gas escapes through the meshes of the cloth, it will be blackened by the sulphur-compounds.

As above stated, all these tests may fail in certain cases, when the amount of sewer-air is small in comparison with the air with which it is mixed. It is therefore to be recommended that the plumbing of houses be examined by an expert at least once a year. *E. H. Bartley.*

[1] Forensic Medicine and Toxicology, 1877, p. 494.
[2] Woodman and Tidy, 1877, p. 492.
[3] Proc. Royal Soc., 1877.
[4] Practical Hygiene, sixth edition, vol. i., p. 148. Wm. Wood & Co.
[5] "Lectures on State Medicine," p. 77.

SEX is a term employed with two significances, which are often confused, but which it is indispensable to distinguish accurately. Originally sex was applied to the organism as a whole, in recognition of the differentiation of the reproductive function. Secondarily, sex, together with the adjectives male and female, has been applied to the essential reproductive elements, ovum and spermatozoon, which it is the function of the sexual organisms (or organs) to produce. According to a strict biological definition *sexuality* is the characteristic of the male and female reproductive elements (genoblasts), and *sex* of the individuals in which the reproductive elements arise. A man has sex, a spermatozoon sexuality.

Sexuality, then, is primitive and essential, and sex is dependent upon it. We consider, therefore, 1, the nature of sexuality; 2, the nature of sex. In a third section a few words will be added on the origin of sexuality.

1. Nature of Sexuality.—The essential facts of sexual reproduction are: that two bodies, partaking more or less plainly of the character of cells, fuse together into a single body, which seems in every respect homologous with a cell, and which undergoes a series of divisions from which result a number of new cells. In all the higher plants and animals the two bodies are obviously different. In all metazoa one body is large, contains a store of nutritive material, and has a special envelope of its own (see Ovum); the other is small, and provided with means of active locomotion (see Spermatozoa); the details of the process of their union are described under Impregnation, *q.v.*

The only hypothesis, as to the nature of the sexual elements, which rests on much basis of fact, is that of Minot.[1] This hypothesis is based upon the consideration of three categories of facts: 1. Sexual reproduction is effected by the union of a male and a female element, which produces a cell; this cell is, therefore, hermaphroditic, or, perhaps, one should say asexual, since it is neither male nor female. It produces other cells by division, and it is probable that the new cells are likewise hermaphroditic or asexual.* 2. When the cell which gives rise to the female element matures into an ovum, it undergoes a remarkable process of unequal division, known as the extrusion of the polar globules. In other words, the cell separates into two kinds of bodies, *a*, several polar globules; *b*, a single female element. 3. Although our knowledge of the development of spermatozoa is extremely unsatisfactory, and although no successful attempt has been made to elucidate what is essential, yet there are reasons for thinking that the parent cell, which generates the male elements, divides during the process into two kinds of bodies, first, a number of smaller corpuscles (spermatoblasts), and second, a single larger structure (mother-cell). The deduction from these premises is evident. In the cells proper both sexes are potentially present; to produce sexual elements the cell divides into its parts; in the case of the egg-cell the male polar globules are cast off, leaving the female ovum; in the case of the sperm-cell the male spermatoblasts, which

* Van Beneden has attempted to give an elaborate proof of this in his paper on Ascaris, but unsuccessfully, as his observations were defective.

by this hypothesis are homologous with the polar globules, are further specialized and employed while the mother-cell atrophies; the mother-cell is homologous with the ovum after the extension of the polar globules.

The hypothesis just outlined is purely morphological, and offers at present no insight whatever into the physiological aspects of sex. It has, however, been adopted provisionally by many writers, Sabatier has carried it somewhat further, having attempted to demonstrate that the central portion of the cell is female, the peripheral portion male. For a more exact statement of these views the reader is referred to Sabatier's original memoirs. In opposition to Minot's view, it has been suggested that the formation of polar globules is merely an atavistic remnant of the process of cell division (Whitman), but this suggestion offers no explanation of the universal fact that the polar globules are always present,* and always entirely different from the ovum proper. Similarly, it has been suggested that the multiplication of the spermatoblasts was an atavistic cell-divisional process (Bütschli), but the evidence in favor of this view is inconclusive. A fanciful comparison between the multiplication of spermatoblasts and the segmentation of the ovum has found favor with some writers, notably with Geddes, but I am unable to recognize any evidence in favor of the comparison.

In regard to the physiological relations of the sexual elements, all sorts of credible and incredible hypotheses—especially the latter—have been advanced. None of them appears to me to deserve mention, unless it be Geddes' speculation that the spermatozoon is the outcome of katabolic changes, and the ovum of anabolic changes; but does not such speculation pass far beyond the present possibilities of science?

According to Minot's hypothesis, then, sexual reproduction consists in the splitting up of cells into sexual elements, and the reunion of a male and a female element to make a new asexual cell. We know from empirical observation that such a new cell has an increased power of growth. It is inevitable, therefore, to suppose that the object of sexual reproduction is just this renovation, or the formation of a new young organism. Why there should be such renovation?—By what physiological change it is accomplished?—are questions to which no answer can be given yet. Weismann has brought forward the important thought that the union of the sexual elements mingles two hereditary tendencies, and so produces variability, and thus helps natural selection. Weismann thinks that this is the only object of sexual reproduction, but I cannot follow him in that.

Parthenogenetic ova develop without impregnation, that is, without the addition of a male element. In accordance with Minot's hypothesis of sexuality, it might be assumed that in parthenogenetic ova the male element was retained, and that the cell remained a true asexual cell and did not become a sexual element. Blochman and Weismann have shown that this is the case by their discovery that in parthenogenetic ova only one polar globule is formed, while there are always two in ova which are impregnated; hence it is probable that one polar globule (by hypothesis male) is retained.†

There are reasons for thinking that the physiological cause of the formation of the sexual elements is defective nutrition. There are numerous observations on plants which indicate this conclusion. Among animals the coincidence between the diminution of growth and sexual maturity may be brought forward as a similar argument. The fact, too, that puberty arrives earlier among the poorer classes, points in the same direction. There is certainly enough evidence in favor of the conclusion that there is a causal relation between impeded nutrition and the development of the sexual elements to more than justify a thorough investigation of the subject.

We may describe the life-cycle as beginning with the union of the sexual elements, resulting in a cell with a great power of growth and multiplication; as multiplication continues the cycle of cells is continued, but the power is gradually exhausted. After a time the exhaustion (impeded nutrition) *causes*, according to the hypothesis just advanced, the formation of sexual elements, and so creates the possibility of a new cycle. The problem of life-cycles has already been discussed in the article on Growth.

2. Nature of Sex.—As a matter of speculation, we must assume that originally the cells could produce both sexual elements in an efficient form at once, but, as a matter of fact, we see that in all (?) known cases only one kind of sexual element is brought to development from one cell. Very early in the evolution of plants and animals, certain cells or groups of cells assumed the special function of producing the sexual elements (genoblasts). Sexual organs were differentiated very early. In the metazoa, originally, the same individual produced both male and female genoblasts, and was therefore hermaphroditic. As evolution continued hermaphroditism was replaced by a new differentiation, in consequence of which the individuals of a species were, some, capable of producing ova only; others of producing spermatozoa only. Individuals of the former kind we call females, of the latter males, and they are said to have sex. In connection with this differentiation there have been evolved manifold secondary modifications, so-called sexual characters, the origin and importance of which were first brought out clearly by Darwin.

The reason why some individuals become male and others female is unknown. Van Beneden advanced the theory that there was a sexual difference between the germ-layers, all male elements arising from one, all female elements from the other. Weismann has shown that this theory was a speculation based upon insufficient observations. In vertebrates the sexual organs (ovaries and testes) arise from the middle germ-layer and out of the genital fold (see Fœtus). At first it is impossible to tell whether the fold is to give rise to an ovary or a testis; on the contrary, the beginnings of the two organs appear identical. This observation leads naturally to the supposition that the sex of the individual embryo is at first non-existent and is determined during the course of development. It is, therefore, noteworthy that nearly all attempts to discover the causation of the sex of an individual seek the cause at the moment of impregnation. Thus we find many hypotheses assuming that the relative condition of the ovum and spermatozoon at the time of their union decides the sex resulting. For example, Hofacker (1828) and Sadler (1830) maintained that when the father was older than the mother there were most sons, but when the mother was the older, then most daughters. Thury thinks that the time of fertilization is important, and that females result if ova are impregnated when freshly matured; males when impregnation is retarded. This view has many advocates, notably Stieda, Berner, Düsing, Girou, and others. Another favorite doctrine is that of relative potency or comparative vigor, according to which the most vigorous of the elements determines the production of its own sex, or, according to some, of the opposite sex. This doctrine has been further elaborated by the assumption that the potency of the sexual element depends upon that of the organism at the time of producing it (Starkweather). Another set of explanations is offered by those who see the *vera causa* of sex in the nourishment of the developing young. Good nourishment is supposed to promote the production of females, poor nourishment that of males. For plants this has been advocated by Girou, Haberlandt, Meehan, and others; for insects, by Gentry and Mrs. Treat; for amphibia, by Yung; for mammals, by Girou, Düsing, etc.

The whole subject urgently calls for a thorough critical revision, based upon proper experiments. At present all we can say is, we do not know why or how sexual individuals are produced.

The *proportion of the sexes* in man has been very carefully studied. The statistics compiled by Oesterlen of

* See discussion in article Ovum.

† Weismann seems to have overlooked this interpretation, which appears obvious and natural, and has endeavored to strain his important observations into an argument against Minot.

59,350,000 births in Europe show that for every 1,000 girls there are 1,063 boys. The result may be confidently accepted, as the proportion of boys in the single countries varies only from 1,052 to 1,072. In animals the proportion varies greatly according to the species; in many mammals females are in excess—thus for 1,000 mares there are only 994 stallions (Darwin); in plant lice the excess of females is enormous, and of some copepods there are plenty of females, but the males are unknown. I do not recall any instance of a *great* excess of males. The best authority on the determination and proportion of the sexes is Hensen (Hermann's "Handb. der Physiol.," Bd. vi., 2 Th., pp. 203–211). Düsing's memoir* is an elaborate and useful compilation.

3. Origin of Sexuality.—It is still uncertain whether sex is co-extensive with life; Weismann maintains that it is not, but was evolved on account of its value in increasing variability; but Weismann disregards some considerations which, I think, have an essential bearing upon the problem. It is, however, certain that the conjugation of unicellular plants and animals is identical with the conjugation of the spermatozoon and ovum (see article on Reproduction, in the Appendix). Indeed, we must assume that sexuality arose before the evolution of life had progressed to the differentiation of animals and plants; since sex occurs in both kingdoms, it is probable that it existed before they were separated and is a common inheritance. This carries sex very far back indeed, and makes it more prudent to recognize the crudity of our knowledge concerning the lowest forms of life, than to attempt premature conclusions about the origin of sex. The evolution of sex in plants has been much studied, and is treated in many text-books of botany—those of Sachs and Goodale may be specified as excellent in this respect. Zoologists have neglected the subject unduly. There is, so far as I know, no good comprehensive treatise on the evolution of sex in the animal series.

Charles Sedgwick Minot.

[1] Theorie der Genoblasten, Biolog. Centralbl., Bd. II., p. 365.

SHARON SPRINGS. *Location and Post-office,* Sharon Springs, Schoharie County, N. Y.

Access.—By the Delaware & Hudson Canal Co. Railroad (Susquehanna Division) to the Springs; or by the New York Central & Hudson River Railroad to Palatine Bridge, thence by carriage nine miles.

Analysis.

One Gallon Contains.	White Sulphur. 48° F. Prof. Lawrence Reid.	Magnesia. 48° F. Prof. Lawrence Reid.	Red Sulphur. 48° F. J. G. Pohle.	Gardner Magnesia. 48° F. J. G. Pohle.	Eye-Water. 48° F. Prof. Lawrence Reid.
Solids.	Grains.	Grains.	Grains.	Grains.	Grains.
Sulphate of Magnesia	34.000	22.700	18.960	19.680	7.500
Sulphate of Lime	85.400	76.000	96.643	93.500	77.500
Bicarbonate of Magnesia	24.000	30.500	0.691	1.360	32.000
Bicarbonate of Soda	......	......	0.492	0.544	......
Bicarbonate of Lime	......	......	12.925	9.698	......
Chloride of Sodium } Chloride of Magnesium }	2.700	3.000	0.333 / 0.730	1.232 / 0.438	2.500
Chloride of Calcium	......	......	0.070	0.162	......
Sulphurets of Calcium and Magnesium	3.000	0.500	0.893	0.625	......
Silicic Acid	......	......	0.450	0.400	......
Total	149.100	132.700	132.187	127.639	119.500
Gases.	cubic inches.	cubic inches.	cubic inches.	cubic inches.	......
Sulphuretted Hydrogen	20.50	3.30	10.50	6.00	......
Carbonic Acid	......	......	4.58	2.22	......
Atmospheric Air	......	......	4.60	3.00	......
			19.08	11.22	......

Therapeutic Properties.—These are celebrated sulphur waters. They are used internally and externally in chronic skin affections, gout, rheumatism, and catarrhal states associated with lymphatic conditions. There are no better waters of this class.

Sharon Springs is situated in a valley, about eleven hundred feet above sea-level, and sixty miles west of Albany. The scenery of the surrounding country is charmingly diversified with hills and vales, while in the distance the peaks of the Adirondacks are visible. The accommodations for guests are ample and of the best, consisting of the main building, "The Pavilion," and twelve cottages situated on a shaded lawn of fifty acres. The bath-house is new and contains all the modern appliances for comfort and convenience. Billiards, bowling, and other forms of amusement are provided for. There are various points of interest within driving distances.

G. B. F.

SHELDON SPRINGS. *Location and Post-office,* Sheldon Springs, Franklin County, Vt.

Access.—By the New York Central & Hudson River and Central Vermont Railroads; or from the east to Lowell, thence by the Central Vermont to St. Albans. From St. Albans the Missisquoi Railroad runs direct to the Springs.

Therapeutic Properties.—This is a delightful alkaline-saline water. It is employed in gastric, uterine, and cystic catarrhs.

* Düsing's article appeared in the Jenaische Zeitschrift, 1884, and has been republished separately.

Analysis (S. Dana Hayes, M.D.).—One gallon contains:

	Grains.
Potash	0.096
Sodium	0.148
Soda	4.012
Ammonia	trace
Lime	1.077
Magnesia	0.166
Protoxide of iron	0.010
Sulphuric acid	0.508
Silicic acid	4.587
Carbonic acid combined	2.115
Crenic acid and organic matter	2.867
Chlorine	0.166
Total	15.752

These springs are situated in the northwestern corner of Vermont, ten miles from St. Albans, on the banks of the Missisquoi River, in a beautiful pastoral country of hill and dale, with Mt. Mansfield and other peaks of the Green Mountains within sight. From a hill near the hotel Lake Champlain can be seen. The hotel, "Congress Hall," stands on the banks of the river, and is fitted with all conveniences for the comfort of its guests. The bath-house is supplied with water from the Sheldon Spring, which flows fourteen thousand gallons per twenty-four hours. In addition to the above spring there are the Central, the Missisquoi, and the Vermont, within a distance of two miles along the Missisquoi River.

G. B. F.

SHENANDOAH ALUM SPRINGS. *Location and Post-office,* Shenandoah Alum Springs, Shenandoah County, Va.

Access.—By the Baltimore & Ohio (Harper's Ferry &

Valley Branch) Railroad to Mount Jackson, thence by stage twelve miles to the Springs.

ANALYSIS.—A qualitative analysis shows the Alum Spring to contain this ingredient in very marked proportion, together with the usual salts and a trace of iron.

THERAPEUTIC PROPERTIES.—As an astringent and alterative this spring is resorted to with success by those suffering from catarrhal diseases of the alimentary tract and urinary apparatus.

This group of springs, eight in number—three alum, a chalybeate, a healing, a sulphur-iron, an arsenic, and a lithia well—are situated in the Shenandoah Valley near the North Mountain, amid the grand and picturesque scenery of that region, at an elevation of over 2,000 feet; there are numerous drives to various points of interest in the surrounding country, over good roads. Hotel accommodations are good. *G. B. F.*

SHOCK. Shock, or collapse, is a sudden, and more or less profound, depression of the vital powers, characterized by general prostration, a feeble pulse, clammy skin, cold extremities; pale, wrinkled, pinched, and shrunken features; faint and sighing respiration, and often more or less impaired consciousness.

The terms "shock," and "collapse," are very properly used synonymously, and yet, while the symptoms are similar or identical, there is often a difference in their application. That condition which is the result of an injury or of an operation, is called shock; while the same group of symptoms arising in the course of some other affection, as peritonitis, strangulated hernia, or hæmorrhage is called collapse. The moribund state is an extreme collapse. It is not practicable to make a distinction in the application of the terms, and no effort will be made to do so in this article.

Syncope resembles collapse in that it comes on suddenly, is attended by weak pulse and respiration, and complete prostration. But in syncope the cause is often mental rather than physical, and the cerebral symptoms are by far the most prominent. Consciousness is lost, as it is not usually in collapse from injury, except in the most serious cases. Furthermore, the symptoms in syncope are generally of a much shorter duration and of a much less dangerous character. On the other hand, the symptoms of collapse are more severe, the danger is greater, and they may be followed by more or less permanent after-effects.

CAUSES.—Among the causes of shocks which call for consideration are the following: injuries, operations, burns and scalds, lightning and electricity, hæmorrhage, poisons, pain, and mental emotions. It goes without saying that the more extensive the injury, the greater will be the shock, and also that the greater the power producing the injury, the more serious will be the result. These facts are noticeable in railroad accidents, and in falls from great heights. A man who has been struck by a locomotive, for instance, will experience a far greater degree of shock than had he been run over by a wagon. The immediate disturbance resulting from a high fall, by which the whole system is jarred and shaken, will be much more severe than that which ordinarily follows a blow from some falling body. Hence the manner of receiving an injury is an important element in the prognosis and treatment.

Injuries to different parts of the body are followed by varying results. A crush of the upper extremity is less dangerous than one of the lower, and is usually attended by less shock. Injuries to the head are proverbially dangerous, and the symptoms of shock are often masked by those resulting from cerebral lesions. Contusions and perforating wounds of the abdomen and its contents, liver, kidneys, intestines, etc., are especially prone to be followed by serious collapse. So are cases of peritonitis from whatever cause, intestinal obstruction, and strangulated hernia. The painful effects resulting from a blow upon the pit of the stomach are familiar to most people. A crushing or laceration of the testicle generally gives rise to profound shock, and a smart blow upon the breast of a woman is apt to be followed by a similar condition.

Severe or prolonged surgical operations are very generally followed by more or less collapse, especially if the operation be attended by much hæmorrhage. This condition is more marked after primary operations for injury, as the shock of the injury is augmented by that of the operation. Secondary operations, performed upon persons of a fairly sound constitution, are much less likely to be followed by severe collapse or shock, from the fact that the system seems to have become habituated to the altered condition. It is a matter of common observation, that a febrile attack, or an acute inflammation, will in many instances protect the system for a certain time, so that an operation of severity may be performed with a fair prospect that the immediate inflammatory disturbance will be comparatively mild. In critical cases it would seem to be wiser to do two operations of moderate severity, than to risk the greater danger attending a single more severe one. The writer has performed amputation at the hip-joint in several instances, by first removing the limb at the middle third of the thigh, and in a few weeks completing the work by disarticulating and removing the remainder of the femur. The shock is thereby distributed, or divided, and while there may be more in the aggregate, yet it does not all come upon the system at once, and hence there is less danger of its overwhelming the vital powers. The extent of shock following an operation depends not alone upon its severity, or upon the idiosyncrasy and condition of the patient, but also upon the time consumed in its performance, upon the amount of hæmorrhage, the length and degree of anæsthesia, the exposure to cold, etc. These matters will receive further attention under the head of prophylaxis.

Burns and scalds involving a great extent of surface, even if superficial, are more prone to produce collapse, than are those of limited area which extend deeply into the tissues. The immediate effects of injuries of this kind to the chest and abdomen are particularly severe. The prostration and pain resulting from inhaling steam or flame are very great, and very frequently the victims die from shock. Similar results are often produced by swallowing caustic or other irritating poisons, as arsenic, corrosive sublimate, oxalic acid, caustic potash, etc.

As might be inferred from the nature of the agent, injuries from electricity are especially severe and dangerous. Lightning often kills instantly, as does the current from the wires used in the modern electric lights. The collapse which results from these injuries, when immediate death does not follow, is often more severe and more prolonged than that following the more common accidents.

Hæmorrhage not only aggravates collapse, but when sudden, severe, or prolonged, it may produce the condition in any degree, from the mildest to the most grave. The more sudden the loss of blood, the greater will be the immediate prostration, and the less are the chances of recovery. A small quantity of blood abstracted from the circulation suddenly will produce more serious effects than a larger quantity taken slowly.

Severe and long-continued pain will aggravate, or may even produce, collapse, as is occasionally seen in some of the neuralgias, like intestinal colic. There can be no reasonable doubt that pain conduced to a fatal result in a case of peritonitis which recently came to the knowledge of the writer. A young lady suffering from this affection was attended by a physician who did not approve of opiates. The result was that the patient tossed upon her bed, and even rolled upon the floor, in her agony, until she finally sank into a comatose state, and died at the end of five days.

Death from shock produced by mental emotion alone must be a rare event. A remarkable case is related by Lauder Brunton, in which some medical students, becoming displeased with a janitor, seized him, and made him believe that they were about to execute him. He was blindfolded, made to kneel before a block, and was then struck a smart blow upon the back of the neck with a wet towel. To their amazement and horror, on removing the bandage the man was dead, literally frightened to death.

The minor effects of strong mental excitement upon the whole system, as well as upon various organs, are matters of every-day observation. Miscarriages attended by severe or even alarming prostration, are occasionally due to mental causes, such as fright, grief, anger, etc. Hysteria, catalepsy, and other affections of the nervous system are familiar examples of psychical disturbances. The unfavorable and even dangerous effects of bad news and other depressing influences upon very sick or very sensitive people are well known to all physicians. Such a shock is as real, and at times as profound, as is that which depends upon some physical lesion, and, moreover, it may be followed by permanent impairment of some function or organ. Deafness has been caused by fright. The normal balance of the nervous system has been permanently impaired in many instances by various powerful emotions, and the patient has been thereby rendered an invalid during the remainder of life.

The degree of shock or collapse resulting from injury, disease, or any cause whatsoever, is influenced more or less by age, and by the physical or mental condition. Some persons are prostrated by comparatively slight injuries, while others sustain very severe ones without having any symptoms of shock. This depends, among other things, upon the natural powers of resistance, upon the frame of mind the patient was in at the time of receiving the injury, and upon the surroundings. Wounds received in battle are often ignored until the excitement of the conflict is over. It is doubtful if sex has much to do with the susceptibility to shock, except in those cases which have some mental disturbance for an exciting cause. It is a common opinion that women bear pain with more patience and fortitude than men, yet it is not certain that they can endure pain of a greater degree, or for a longer time, than men. For example, it is seldom that a man dies from the shock and exhaustion of a fractured hip, but old women not infrequently succumb to this injury.

Weak and debilitated people, and those having a "lax fibre," both mentally and physically, suffer from shock to a greater extent than the strong and robust. The victims of alcoholism withstand shock, as well as most affections of the nervous system, poorly. They frequently, in such cases, suffer from delirium tremens, mania, or other complications; while the rallying power is diminished, the convalescence is prolonged, the prognosis is more unfavorable, and the effects of all kinds of treatment are often anything but satisfactory. The very young and the very old are peculiarly susceptible to shock and collapse. The symptoms are more pronounced in the former, but more lasting and more dangerous in the latter. A temporary collapse is very common in children after many operations and injuries of no great severity. While it is not a very dangerous condition under most circumstances, yet it is to be looked for, and is to be carefully watched until it disappears. Quiet and artificial heat are all that will usually be required in the way of treatment. On the contrary, in the aged the symptoms of shock are frequently mild in character, but they do not pass away, as might be expected. They are apt to persist, and finally to merge into some more serious and perhaps fatal condition.

Symptoms.—The symptoms of shock or collapse are strikingly characteristic, and once seen they are not easily forgotten. The vital powers are profoundly prostrated. The patient lies perfectly still upon his back, too weak to move, and almost too weak to breathe. The pulse is feeble, quick, irregular, or absent; the sounds of the heart are indistinct, or perhaps inaudible; the inspiration is faint, sighing, and slow; the features are pinched and shrunken; the lips pale and livid; the eyes dull, sunken, and often turned upward; the pupils dilated and sluggish; the skin is pale, cold, and clammy; the sweating is at times profuse; the extremities are cold, and the nails purplish. The temperature falls in proportion to the severity of the shock, the depression sometimes exceeding two degrees. Except in the most unfavorable cases, or in those complicated with injuries to the head, the intellect is usually clear and unimpaired. The patient may be perfectly conscious, and yet be too weak to speak, or to notice his surroundings, or his own sensations, unless he be in severe pain. There may be vomiting, which is a sign of reaction, or hiccough, and the sphincters may be relaxed.

In other instances the patient is extremely restless, throwing himself about first in one position and then in another, but is easy in none. Tossing of the arms, gasping for breath, and calling for water are common and unfavorable symptoms attending a severe hæmorrhage. The mind under these circumstances is usually clear, the voice is strong, but vision may be lost. At times the patient suffers the most intense agony from fear of impending death. Travers, in his valuable work on "Constitutional Irritation," has called this restless stage "prostration with excitement," and the term exactly expresses the condition. It is to be borne in mind that, while in this state, the patient is on the brink of dissolution, and that great care is required in performing operations to prevent collapse. The power of resistance seems to be reduced to the lowest point, and a little additional shock suffices to turn the scale the wrong way.

A peculiar, as well as deceptive, form of collapse is occasionally seen in cases of strangulated hernia. The pain and vomiting, after persisting for a period varying from two to five or six days, finally subside, leaving the patient quiet and comfortable; he talks rationally, and with some strength. To a casual observer he seems to be convalescent. But he has no pulse at the wrist, or at best an extremely weak one. Patients in this condition generally die inside of twenty-four hours, and any operation performed to relieve the strangulation will only hasten the end.

The term "shock" has of late years been applied to a peculiar condition of the nervous system, which is usually the result of a railroad accident. A person is in a collision, for example, and receives a severe shaking up, perhaps in the form of a violent to-and-fro motion. He crawls out of the wreck apparently unhurt, with the exception of a few unimportant bruises. Perhaps he assists some of his fellow-travellers, or goes on his way to his destination. In the course of some hours or days after the accident he begins to feel nervous and restless; is easily frightened or excited; cannot sleep; has headache, pains in his back and in various parts of the body. He is depressed, hypochondriacal, loses his interest in everything and in everybody except himself and his own sensations; his appetite fails, and he grows thin; becomes weak both mentally and physically, and presents the appearance of premature old age. He is said to be suffering from "shock to the nervous system." The normal poise or equilibrium is for the time destroyed.

These symptoms, as will readily be seen, are entirely unlike—both in character and in the time of their appearance—those met with in the ordinary cases of shock following an injury. Their course, duration, and treatment are also very different. It is a singular fact that cases attended by symptoms of shock immediately after an accident, seldom develop the symptoms peculiar to "shock to the nervous system." This peculiar affection is so frequent after railroad accidents, although not wholly confined to them, and so often involves a question of suit at law for personal damages, that the various complaints have received the name of "litigation symptoms." Experience proves, however, that they have a real existence, and that they may persist for a long time, or may even result in some permanent affection. Yet the tendency, in the great majority of cases, is toward recovery.

Experimental physiology has demonstrated that in shock there is a reflex paralysis of the heart and abdominal vessels through the medium of the vaso-motor system. "The slow, feeble, or almost annihilated pulse, the pallor of the lips and coldness of the extremities, the mental hebetude, the anæsthesia of the surface, the relaxation of the sphincters, the lessened secretion of the urine, the impaired muscular action,"[1] all indicate the effect of a more or less severe paresis of the heart and vessels, and its accompanying impression upon the whole nervous system.

"Shock is an example of reflex paralysis in the strictest and narrowest sense of the term—a reflex inhibition, probably in the majority of cases general, affecting all the functions of the nervous system, and not limited to the heart and vessels only." [2]

PROGNOSIS.—To arrive at a reasonable prognosis in a case of shock or collapse, the nature of the injury, the character of the symptoms, their course and duration, and the age and previous condition of the patient, must receive careful consideration. The longer the symptoms have persisted, the more unfavorable will be the prognosis. Should reaction be delayed more than eight or ten hours, in cases not complicated with head injuries, the outlook is very serious, although by no means hopeless, as many patients have recovered after a much longer time. The greater the force producing the injury, and the more profound the collapse, the greater the danger of a fatal result. Deepening of the stupor, or increased restlessness with diminished force of the pulse, persistence of the pallor and of the coldness of the surface, profuse sweats, inability to swallow, insensibility of the pupils, persistent vomiting, and relaxation of the sphincters, all betoken the greatest danger, and are seldom followed by recovery.

On the contrary, returning consciousness, "coming to himself," as it is commonly called, increasing interest in the surroundings, a stronger and steadier pulse, deeper and more regular breathing, warmer and drier surface and extremities, more natural color and expression, a brighter eye, an increasing muscular power enabling the patient to change his position at will, are all favorable symptoms. They indicate a healthy reaction, and promise a favorable termination so far as the immediate results are concerned.

In some instances reaction sets in well, progresses to a certain stage, and then stops, leaving the patient in a weak and unsatisfactory condition, which may persist for an indefinite period. Again, the symptoms of collapse may recur after having entirely disappeared, and the patient may be brought to even a worse condition than he was in during the primary shock. These secondary attacks of prostration should lead to the suspicion of some internal lesion, or of some organic change, which had not hitherto been discovered. Hæmorrhage, extravasation of urine, perforation of the intestine, embolism, or other internal injuries and affections must be thought of, and the proper means taken to determine their existence.

Temperament is an important factor in the prognosis of shock, especially in that form which follows surgical operations. The hysterical or neurotic temperament is a particularly troublesome one. Slight operations upon these persons are often followed by great nervous excitement and pain, which are out of all proportion to the severity of the treatment. The symptoms are persistent, and, as a rule, they are not very responsive to the action of drugs. The convalescence is not only longer, but the final result is more doubtful. The writer is cognizant of an instance in which a tenotomy of the tibialis anticus in a young lady was followed by the most alarming collapse, as well as by many months of severe prostration. In short, the patient has never been as well as she was before. Operations of expediency should be performed upon this class of people only after the most careful consideration, and with the expectation that the subsequent effects may be much more serious than they would be under ordinary circumstances. As a rule, patients who are courageous, cheerful, and hopeful do better than the irritable and despondent. Those individuals who ask for an operation for the cure of some surgical affection, have their minds prepared to a certain extent for the ordeal, and therefore they undergo the trial better than those who are suddenly struck down in robust health by an accident, and are compelled to submit to an operation. In the former case the system is somewhat prepared for the state of invalidism which the patient is obliged to lead for a time, and the change in habits is much less in degree, and hence is productive of much less disturbance both mental and physical.

TREATMENT.—In slight cases of shock little is required in the way of treatment beyond keeping the patient warm and quiet, and thus allowing the vital forces to regain their normal condition. Too much dosing with drugs and stimulants under these circumstances does more harm than good.

In the severe cases, however, much can be done, and much can be left undone, to aid the patient's recovery. The main indications for treatment are to preserve and supply heat to the body; to keep the heart going; to control restlessness; and to treat the complications, as hæmorrhage, etc., according to the indications and opportunities. A person suffering from shock should be placed in an easy position upon his back, with his head low. He should be surrounded by bottles of hot water, or hot bricks, or whatever is most convenient, care being taken that the skin is well protected from being burned, a not uncommon accident in these cases. He is to be warmly, but not too heavily, covered with blankets, and if such an article is at hand, by a rubber sheet. The patient is to be moved about as little as possible. The clothing should not be changed unless it is wet or unless there is some absolute necessity calling for the change. He should not be bathed nor "tidied up" for the sake of appearances. The physician's examination should be conducted as quietly and as gently as possible, and need be carried only far enough at the time to determine the danger, and to indicate the treatment immediately required. Unnecessary handling and moving, changing the clothes, etc., only tend to increase the exhaustion. Hæmorrhage should be checked in the speediest and most efficacious manner, and the wounds should receive as little treatment at the time as is compatible with the future well-being of the patient.

As the processes of digestion and absorption are more or less in abeyance during collapse, it is useless, and worse than useless, to give the patient a large quantity of food or stimulants by the mouth. The stomach in many instances will retain everything for a time, but no symptoms of reaction manifest themselves. Finally, vomiting sets in, and the ejected matters show that the stomach has been inactive, and incapable of performing its functions. Time has thus been lost, and the depression has been steadily increasing. It is better to delay the administration of food until partial reaction has taken place, but stimulants are indicated from the first in proportion to the degree of collapse. To get the speediest and surest effect from them they should be given hypodermically. A syringeful (ʒ j.–ij.) of sulphuric ether, brandy, or other liquor may be injected into the arm, or other convenient part of the body, at intervals of five or ten minutes, or less frequently, until signs of reaction manifest themselves, when the intervals are to be lengthened, and small quantities may then be given by the mouth and rectum. When a fair amount of reaction has become established, food, in the form of milk and lime-water, beef-tea, etc., should largely supplant the stimulants.

Restlessness and pain are best controlled by morphine given subcutaneously. The drug acts as a strong, steady, and continuous stimulant, and it is a most valuable agent to maintain the vital powers in shock, as well as to prevent this condition. The dose may vary from one-twelfth to one-fourth of a grain, according to the indications, always taking care not to repeat the dose often enough to get the narcotic effects of the drug. The stimulant action, and not the soporific, is desired under these circumstances.

Digitalis has been recommended for its stimulant effect upon the heart and circulation. It may be given under the skin or by the mouth, preferably by the former method to get the effects speedily. The dose is half a drachm of the tincture, which is to be repeated every hour until signs of improvement are apparent.

Transfusion, or what is more practicable, and probably fully as efficacious, an intravenous injection of salt-water, is indicated in collapse resulting from hæmorrhage, but not under other circumstances. The great advantage of the saline injection is that it is always at hand, and can be used with a fountain, or any other good syr-

inge which carries a steady stream, and which can be filled while in position. The solution should be warm, and the proportion of salt should be about a drachm and a half to the quart. The following formula, suggested by Mikulicz, may be used, if time is not pressing:

Sod. chloridi	ʒ jss.
Sod. bicarb.	gr. xv.
Aq. destillatæ	O ij.

M.

The solution should be raised to a temperature of 100° F., and it is to be injected very slowly, and in quantities varying from one to four pints. The pulse and respiration are to be carefully watched during the operation. The simplicity of this mode of treatment, as well as the favorable results which follow it, are strong arguments in its favor.[3]

It is more than doubtful if venesection is required in those cases of collapse attended by congestion of the surface and distended jugulars. "The heart is distended because it is paralyzed, and not paralyzed because it is distended."[4]

Authorities are pretty well agreed that surgical operations should not be performed while a person is in a profound collapse. The shock of the operation added to that of the injury augments the danger, and thereby diminishes the patient's chances for recovery. The claim put forward by some writers, that the stimulant effects of sulphuric ether counterbalance the depression of the operation, is not sustained by experience. It is true that the primary effect of ether is stimulating, but it is of short duration, and is not to be relied upon. If the anæsthesia be profound, or if it be kept up for any length of time, the subsequent prostration is frequently alarming.

The operation should always be delayed, if possible, until a fair reaction has become established. The exact stage of reaction which justifies a resort to operative procedures is to be decided by the condition of each individual case. A weak, irregular pulse, sighing and irregular respiration, cold extremities and cold sweats, contra-indicate an operation. On the other hand, an operation may be undertaken when the patient is fully aware of what is going on around him, when the pulse is regular and of fair strength, the surface is warm, and the breathing natural. No regrets need be entertained by the surgeon because a patient dies from shock without an operation. If he could not rally from the collapse alone, he certainly could not do so after an additional burden had been put upon him.

Unconsciousness from shock, not complicated with head injury, is an exceedingly grave symptom, and, as a rule, precludes an operation. Should it be necessary to perform one under these circumstances, no anæsthetic is required. It is not necessary to control pain, as the patient, being unconscious, feels no pain. Neither is the ether called for as a stimulant, because there are other and better methods of stimulation. Should the patient be sensible to suffering, a very little of the anæsthetic, administered at the commencement of the operation, is of great value. It quiets the nervous system, deadens or prevents pain, and if used rightly, it does not add to the shock and subsequent prostration.

Prophylaxis.—This subject is of so much importance, that a few concluding sentences may be devoted to its consideration. Very much can be done to prevent collapse after surgical operations by paying special attention to the following points: Temperature, time, hæmorrhage, degree of anæsthesia, and personal disturbance. It is a great mistake to suppose that the time consumed in performing an operation is of little importance so long as the patient is under the influence of an anæsthetic, and hence not conscious of suffering. There can be no doubt that the longer a person is subjected to an operation or to an examination, the greater will be the shock to the nervous system, and the greater will be the subsequent prostration. Deep or long-continued anæsthesia augments the unfavorable symptoms. The patient may seem to be going on well under an operation with full anæsthesia, when suddenly the pulse fails, the strength vanishes, profuse sweats break out, and the patient is in collapse. The operation is either hastily concluded or abandoned, and hours are consumed in efforts to keep the person alive. This state of affairs may often be avoided by giving just enough ether to deaden the pain of the primary incisions, and perhaps the dividing of the bones, and by being as expeditious as possible in all the manipulations. It is advisable to give a moderate dose of morphine (gr. $\frac{1}{12}$ to $\frac{1}{4}$) under the skin, previous to etherizing any patient who is about to undergo a critical operation. The strength is sustained thereby, less ether is required, and the suffering is mitigated. In many instances so little of the anæsthetic is required, under these circumstances, that the operation may be said to have been done under the primary effects of the agent.

It is, of course, important that all possible precautions shall be taken to prevent hæmorrhage, and, in case of its occurrence, that it should be controlled in the speediest and most effectual manner. It is not necessary, in most instances of peril, to apply ligatures to all the bleeding points, as the hæmorrhage from the smaller vessels may be stopped by compress and bandage. Neither is it wise to consume too much time in the toilet of the wound under these circumstances. The object should be to get the patient into a warm bed as soon as is compatible with safety, and many minutiæ of the final dressing may therefore be omitted for the time being. For example, in an excision of the scapula, which was necessarily a long and bloody operation, the principal vessels were tied, the wound was hastily closed, the dressing quickly applied, and the patient, being wrapped in warm blankets, was carried up-stairs feet foremost, and put to bed, where he was allowed to remain undisturbed for three days. At the end of that time he had rallied sufficiently to allow of his being cleaned up, and having his dressings and clothing changed. As it is the little things which tell in these critical cases, they are worthy of notice.

The preservation of animal heat is of the greatest importance, and especial attention should be paid to the matter. Heaters in the shape of hot bricks, or jugs or bottles of hot water, are to be placed about the patient, care being taken that they shall not touch the flesh, and thus possibly be the means of producing an eschar, a not infrequent occurrence. He should be warmly, but not too heavily, covered with blankets, and he should be moved about or disturbed in any way as little as possible, because all these things increase exhaustion, disturb the circulation, and prevent rest. In a desperate case of pyæmic suppuration of the knee-joint, at the Boston City Hospital, an amputation of the thigh was successfully done without removing the patient from his bed. He was not under ether over three minutes, and the shock was only moderate.

A man entered the hospital suffering from a large sarcoma of the knee, of rapid growth. He was in a state of extreme exhaustion. Pulse, 150; temperature, 103°F.; pale, weak, and emaciated. Preparations having been made, he was brought from the ward in his own bed, given a hypodermic injection of morphine (gr. $\frac{1}{6}$), and after inhaling a little ether, he was transferred to the table, still being surrounded by heaters, and covered with blankets and a rubber sheet. The thigh was quickly amputated by the circular method, and as soon as the bone was sawn the ether was removed. Not over three ounces had been consumed, and the patient had not been unconscious more than five minutes. Hardly any shock followed the operation, and in twenty-four hours the temperature was normal. He speedily recovered from the operation.

Another patient, suffering from extensive and long-standing necrosis of the femur, was brought to the lowest state of exhaustion before allowing surgical interference. He finally consented, and under all the precautions mentioned above, the limb was amputated at the hip-joint by making a long external incision, disarticulating the head of the femur, and dividing the soft parts at a single sweep of the knife. The subsequent shock was not serious, and he made a good recovery. Upon the same day

another amputation at the hip was performed upon a boy, the victim of hip disease. The head of the bone had been removed by excision a few weeks previously. The patient was in a most wretched condition, emaciated to the last degree, with high temperature and rapid pulse, suppuration extending in all directions, into the pelvis, through the acetabulum above the pubes, and down the thigh. The operation was performed quickly, and all possible precautions were taken to guard against shock and prostration. For several days he had a high temperature, with sweats, delirium, restlessness, and even vomiting. He finally rallied, gained strength and flesh, and was out-of-doors upon crutches, when symptoms of tubercular meningitis suddenly made their appearance, and he died three months after the amputation.

These cases serve to illustrate the importance of the principles advocated in this paper, and by following them carefully it is firmly believed by the writer that many patients, who are in an apparently hopeless condition, can be carried through a critical operation with safety.

Briefly stated, these principles are as follows: Keep the patient warm. Avoid exposure to cold. Save time, and prevent hæmorrhage to the fullest extent possible. Stimulate and feed by the skin and rectum. Put little or nothing into the stomach until reaction sets in. Give the smallest possible quantity of anæsthetic that will control the major portion of the pain. Disturb the patient as little as possible, and get him into his warm bed as soon as is compatible with a proper performance of the operation. *George W. Gay.*

[1] H. W. Page: Injuries of Spine and Spinal Cord, p. 145.

[2] Mr. C. W. Mansell-Moullin: International Encyclopædia of Surgery, vol. i., p. 369.

[3] Dr. F. B. Harrington: Boston Medical and Surgical Journal, vol. cxiv., Nos. 9 and 21.

[4] Mansell-Moullin, loc. cit.

SHOULDER-JOINT. The articulation between the shoulder-girdle and the humerus. The cavity for the reception of the head of the humerus is called the glenoid fossa, and in animals possessing a separate coracoid bone it is formed by the union of the coracoid and the scapula. In man the coracoid unites with the scapula at an early age, but a trace of the primitive condition is found in fœtal life, for the embryonic coracoid forms a portion of the fossa.

Like the corresponding articulation of the lower extremity, it is a ball-and-socket joint, and in low mammals the two are very similar in other anatomical characters. But as the hip-joint becomes more solid and firm by reason of the necessities of the erect position, so the shoulder-joint becomes freer and more movable when the limb is no longer required to support the body, and less strain is put upon the investing capsule. It is, therefore, one of the loosest joints in the body, depending for its strength less upon the ligaments which unite it and the shapes of the articular surfaces, than upon the muscles which surround it and form a series of active ligaments, so to speak, as their tension may, under ordinary circumstances, be adjusted to the needs of the occasion. Owing to these peculiarities, dislocations occur at the shoulder-joint more frequently than at all other articulations in the body put together, and usually when the muscles are taken off their guard. In reducing the dislocation here it is advisable to remember this peculiarity of the muscles, and to attempt the operation when the patient's attention is attracted elsewhere, or when relaxation has been produced by an anæsthetic.

Outside of the joint proper, with its investing capsule and the muscles immediately in relation with it, there is a secondary investment, consisting of what may be called the acromio-coracoid arch (viz., the acromion process, the coracoid process, and the ligament that stretches between), and the deltoid muscle, which folds down over the shoulder as a dense triangular mass. The deeper structures play against the superficial ones, and large bursal spaces are thus formed, so that there is a secondary imperfect articulation outside of the true one. When we add to these peculiarities the fact that the joint is rendered adaptable for still freer movement by the possibility of shifting the scapula either laterally, or by tilting it upward and downward, it will be seen that we have a mechanism more easily adapted to a great variety of positions, and with a far wider range of motion, than any other joint in the body.

The articular surfaces involved are the large semi-globular head of the humerus (see Fig. 3520), and the comparatively small glenoid fossa of the scapula, deepened slightly by the rim of fibro-cartilage called the glenoid ligament (see Fig. 3521). The area of the cup is about one-third that of the head of the humerus. Examining the latter with great care before the articular cartilage has been removed, it will be seen that the surface involved in the articulation comprises about two-thirds of a sphere, but that the lateral half differs slightly in curvature from the median half, the dividing line being defined above between the coracoid process and the greater tuberosity, below by the scapular head of the triceps. For motions toward the anterior plane of the body there is, therefore, a different set of articular surfaces used from those which relate to the posterior plane. The greatest measurement is in a horizontal direction, indicating the wide extent of the forward and back movement of the arm, and this greatest diameter lies about midway between the upper and lower edges. The greatest vertical diameter lies about in a line with the bicipital groove, and indicates the plane in which the greatest excursion takes place upward and downward. This plane, if produced, cuts the articular surface of the lower end of the humerus obliquely, and usually falls behind the inner condyle. Considerable variation in this occurs in differ-

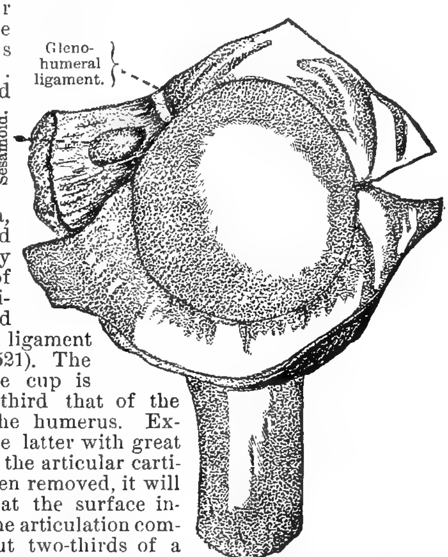

FIG. 3520.—Head of Humerus, with Part of Capsule Attached. (Morris.)

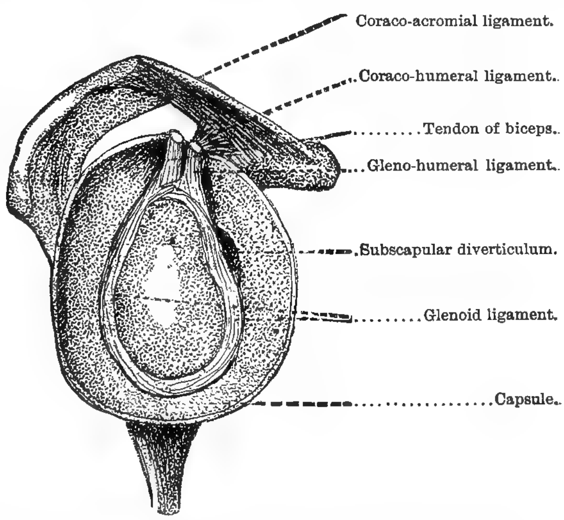

FIG. 3521.—Glenoid Fossa of Scapula, with Part of Capsule Attached.

ent individuals, and it is found that, as we descend to lower races, the angle between the axes of the articular surfaces of the upper and the lower ends of the humerus becomes constantly greater. In the apes this increase becomes still more marked. As movements directly toward the median line are soon checked by contact with the body, there is much more of the articular surface above the horizontal axis of the humeral head than below it.

The head is joined to the shaft by means of a slight constriction marking the attachment of the capsular ligament, called the anatomical neck. A line perpendicular to the central portion of the head represents the axis of this neck. It cuts the axis of the shaft at an angle of about 140°, which may be compared with the angle which the neck of the femur makes with the shaft, viz., 131° in adults. From observations made upon young bones Krause concludes, however, that the anatomical neck is not strictly comparable with the neck of the femur. If we take a humerus of a subject about fifteen years of age, in which the proximal epiphysis has not yet united, and make a horizontal section of it through the greater tuberosity, it will be seen that a strong spur-like projection extends upward and inward from the diaphysis, resembling the similar structure which forms the neck of the femur. This becomes completely encapped by the epiphysial ossification. He regards this as the real neck of the humerus, concealed within the centre of the bone. This may, perhaps, be a vestige of the time when the humerus really possessed a markedly constricted neck.

The cartilage on the head is thickest about the middle, that is to say, at the place where the bone strikes most forcibly when the arms are extended, as in pushing.

The glenoid fossa (Fig. 3521) contrasts markedly with the acetabulum of the hip-joint, being very shallow and much more limited in extent. Instead of having a spherical form it is of an irregularly oval shape, somewhat like a pear, with the large end downward, resting on the strong axillary costa of the scapula, while the upper narrower portion is at the root of the coracoid process. The slight notch on the inner side between these two is a vestige of the original division of the cavity into two parts, one belonging to the coracoid bone, the other to the scapula proper, thus resembling the constitution of the acetabulum. The bony fossa is deepened, as in the hip, by a rim of fibro-cartilage called the glenoid ligament. This is triangular in section, its fibres are concentrically arranged, and it bridges over the slight notch as the transverse ligament does the acetabular notch. Its outline does not exactly fit the head in all positions, but its elasticity allows it to adapt itself to the surface whenever the arm is moved. At the upper part of the glenoid rim the tendon of the biceps muscle of the arm is attached, its fibres passing around and blending with the fibro-cartilage. The tension of the tendon assists in holding the rim firmly against the head, and takes some pressure off the cavity. It has been suggested that the glenoid ligament is merely the remains of a former, somewhat more extensive, insertion of the biceps; that its coracoid head and glenoid head were formerly united in a single muscular sheet which had insertion around the glenoid fossa. No comparative evidence has been adduced for this view, as far as I am aware. The tendon is not so strongly blended but that it can be torn away from its glenoid attachment without detaching the cartilage.

The osteo-cartilaginous cavity thus formed for the humeral head measures only about one inch and a half in its vertical diameter, and an inch horizontally at its widest part. When the scapula is at rest it looks outward, forward and a little downward. It is a little more prominent on the inner side, to counteract the pull of the muscles and the result of blows on the shoulder, which tend to displace it in that direction. The cartilage is thickest at the edges and lower part of the cavity, as it is here that the greatest pressure is received in carrying weights and also in lifting, for the muscles above the joint (biceps, supraspinatus, and infraspinatus) hold the head firmly against this portion. Notwithstanding the sharpness of the edge of the glenoid ligament, imperfect luxations have been noted in which the humerus rested upon it. It is difficult to see how this apparently unstable position could be maintained without there being at the same time a rent in the capsule through which the head extruded, and which thus fixed it.

The capsule of the joint (Fig. 3522) forms a complete

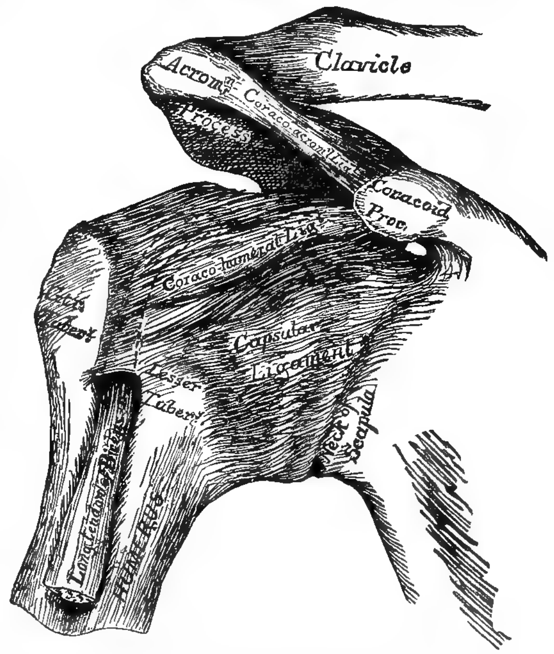

FIG. 3522.—Capsule of Shoulder-joint. (Altered from Heitzmann.)

conical investment attached by its truncated summit to the scapula at the edge of the glenoid fossa. For the greater portion of its extent it is blended with the outer margin of the glenoid ligament. This blending is most complete at the bottom, where it springs immediately from the edge of the ligament; on the sides it is less so, leaving the edge free in the joint-cavity; while above it leaves the ligament and is attached to the base of the coracoid process, affording a free margin for the insertion of the biceps tendon. Upon the humerus it is attached just beyond the articular surface at the base of the tuberosities, except at the bicipital groove, which it bridges over in order to allow the tendon of the biceps to enter the joint-cavity, and below, where it extends for a short distance downward upon the surgical neck. Resection within the capsule is therefore possible, and a pure fracture of the anatomical neck must always be intra-capsular. Some instances of this surgical curiosity are on record, and they almost invariably end unfavorably, as the head appears to be cut off from all nourishment and no union is possible. The capsule is very lax, and would admit a humeral head of twice the size of the actual one. Thus

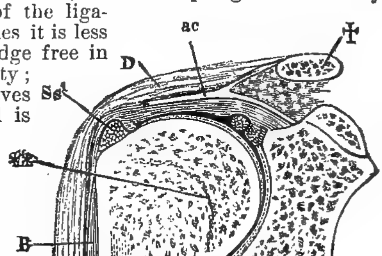

FIG. 3523.—Frontal Sections of the Shoulder-joint while the arm is hanging. (Henle.) †, clavicle; *ac*, acromio-coracoid ligament; *D*, deltoid muscle; *B*, tendon of long head of biceps; *Ss*, subscapularis; *Ss*1, supraspinatus; *Al*, triceps; *Tmj*, teres major; *, posterior circumflex artery; **, trace of epiphysial union.

the arm is never checked in its motions, except at the limits of its course. In the ordinary position, when the arm hangs loose (Fig. 3523), the capsule forms a pocket reaching downward as far as the teres major, and is united there to the periosteum of the upper end of the humerus by loose connective tissue. This pocket may receive any products of effusion or inflammation, and be felt as a fluctuating body in the axilla. When the arm is lifted away from the side (Fig. 3524), it becomes obliterated, and the motion is checked by the tension of the capsule as soon as it has reached a right angle. This is as far as the arm can be lifted without calling in the aid of the scapula. The laxity of the capsule is so great that when effusion occurs into it the bones may be pushed apart to the extent of half an inch, which explains the lengthening of the arm often seen in cases of this kind. When the extension reaches the maximum the elbow is pushed a little backward and the arm rotated inward. If the muscles are all dissected off, the head of the humerus still remains applied to the glenoid fossa, but if the capsule is penetrated, it at once drops considerably. This shows that the articular surfaces are kept in contact by atmospheric pressure, as is the case in the hip-joint. By no other means could the arm have been suspended against a shallow socket with such freedom of motion.

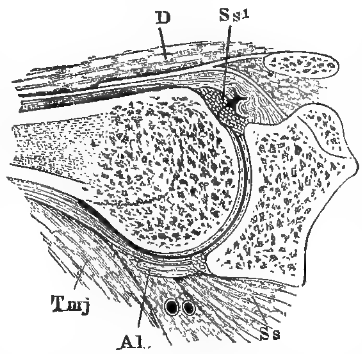

FIG. 3524.—Frontal Section of the Shoulder-joint while the Arm is lifted Horizontally. (Henle.) *D*, deltoid muscle; *Ss*, subscapularis; *Al*, triceps; *Tmj*, teres major.

The capsule is composed of bundles of tissue mostly of the white fibrous variety, but with yellow elastic fibres sparingly intermingled. Some of these run longitudinally, some obliquely, while a deeper set run circularly, parallel to the capsular insertions. A great number of vessels and nerves ramify between these bundles, and there is constantly a considerable quantity of fatty matter, even in lean persons (Sappey).

As there are no great strains put upon it habitually, the capsule does not show the marked differences in thickness which characterize that of the hip-joint. Differences do, however, exist, and are of two kinds, viz., those caused by accessory bands thickening the bundles of the capsule proper, and those caused by the union therewith of the tendons of the muscles which have their insertion near by. Several distinct thickening bands have been described. Among these the coraco-humeral ligament is the most important (see Figs. 3522 and 3525). It arises from the base of the coracoid process immediately below the acromio-coracoid ligament, and passes over the capsule to the greater tuberosity. From its situation it is sometimes called the suspensory ligament of the humerus, and it is indeed likely that the conditions of strain caused by the weight of the arm have occasioned the formation of this band. Sutton, however, considers it a vestige of a former insertion of the pectoralis minor. He finds that in some apes that muscle has an insertion upon the greater tuberosity of the humerus, and concludes that it has been displaced from that to the coracoid process, leaving the coraco-humeral ligament as the atrophied remains of its tendon.

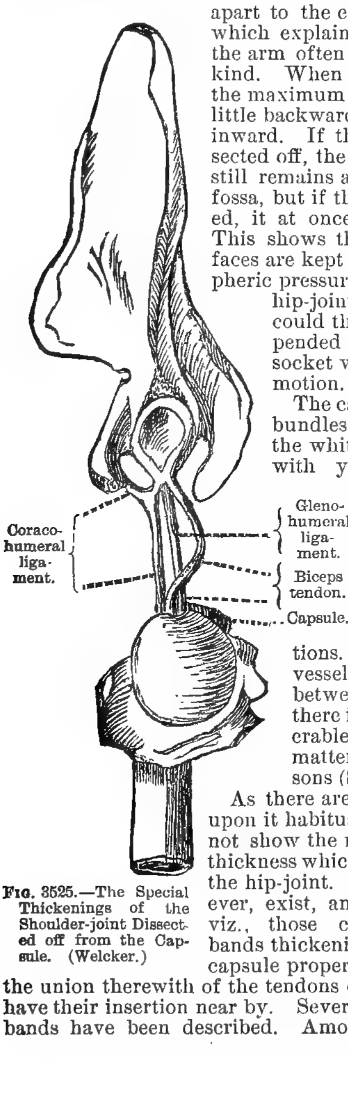

FIG. 3525.—The Special Thickenings of the Shoulder-joint Dissected off from the Capsule. (Welcker.)

Connected with the coraco-humeral ligament is another deeper structure which appears as a fold of synovial membrane, arising from the margin of the glenoid fossa and passing down with that ligament to the humerus. This fold has received various names. It appears first to have been noticed by Schlemm, who called it the *ligamentum glenoideo-brachiale internum* or *innere Schulterband*. Flood called it the gleno-humeral ligament, which is the name generally used by English anatomists. Sappey calls it the coraco-glenoid ligament, tracing it from the coracoid process. Welcker, who has made a careful comparative study of it, describes it as a posterior column of the coraco-humeral ligament, and in this he is followed by most recent German authorities. He considers the two structures as analogous to the ligamentum teres of the hip-joint. His view of their connections when dissected away from the capsule is shown in Fig. 3525. Sutton, who believes that most cord-like ligamentous structures represent the atrophied vestiges of muscles that have formerly been active around the joint, suggests that the gleno-humeral ligament is the relic of a former insertion of the subscapularis muscle. By an examination of many shoulder-joints of lower animals, he finds the ligament constantly present whenever the ligamentum teres is developed in the hip-joint, and traces the whole series back to a muscle which in *Menobranchus* corresponds to the subscapularis of man, and traverses the shoulder-joint very much as the human biceps tendon does. It is generally thought, however, that the structure in question is merely a thickening of the capsule, caused by the play of the biceps tendon against the synovial membrane.

Other accessory bands are described by some authors, viz., an *inner ligament* passing from the inner edge of the glenoid fossa along the lower margin of the subscapularis tendon to the lesser tuberosity, and the *inferior ligament*, which passes from the under edge of the glenoid cavity to the under part of the anatomical neck. These bands appear to be nothing more than the thickenings which naturally take place in the capsule where it is not strengthened by the tendons of muscles. The inner band is usually stretched or torn in subcoracoid dislocations, and the inferior one when the arm is wrenched so as to drive the head through into the axilla, producing the subglenoid dislocation. When this occurs, it may permanently injure the capsule so that whenever the arm is uplifted a dislocation takes place, by the action of the muscles which pull upon the tuberosities.

The tendons of the muscles associated with the joint strengthen it far more efficiently than do any bands of the capsule. They form around the articulation an incomplete hollow cone, with its base at the shoulder-blade and its apex at their humeral insertion, so that the capsule and the muscular investment appear like two interpenetrating cones with their bases in opposite directions. The tendons embrace about three-fourths of the upper surface, the wide tendon of the subscapularis being on the medial side, the teres minor and infraspinatus laterally, and the supraspinatus above. The union of the tendons with the ligaments is not as intimate as at the knee-joint; with care they can usually be dissected off. Beneath the tendons the capsule becomes extremely thin, and under the subscapularis it is deficient, so that the synovial membrane is in immediate contact with the tendon. The subscapularis has usually a small sesamoid

developed in it (Fig. 3520), where it rubs against the lesser tuberosity. Some of the fibres of the long head of the triceps become blended with the lower part of

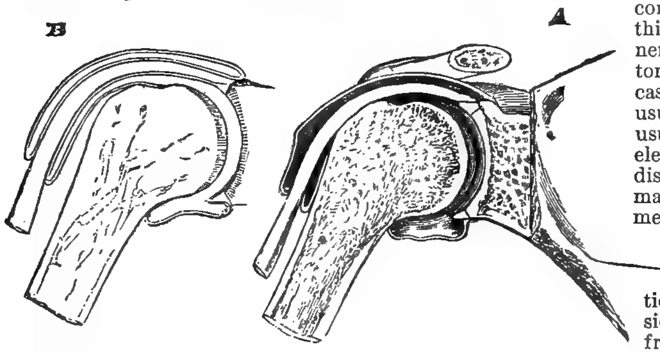

FIG. 3526.—A, Section Showing the Relation of the Long Tendon of the Biceps to the Shoulder-joint. B, is an outline showing the Arrangement of the Synovial Membrane. (Allen Thomson in Quain's Anatomy.)

the capsule, and no doubt tend to draw it downward and prevent it from being nipped when the arm is brought toward the side.

But the most interesting feature of the muscles about

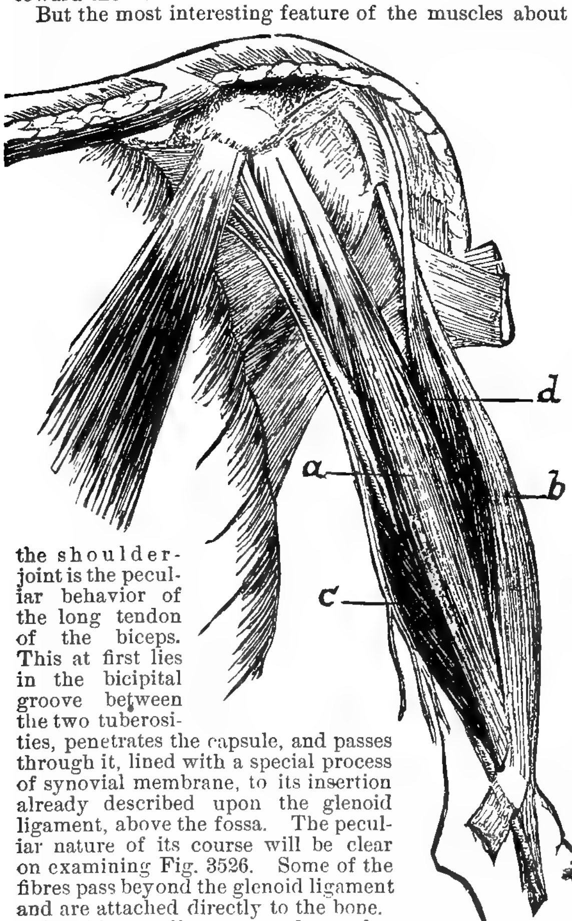

FIG. 3527.—Abnormal Arrangement of the Biceps. *a*, Coracoid head; *b*, glenoid head; *c*, humeral head; *d*, capsular head.

the shoulder-joint is the peculiar behavior of the long tendon of the biceps. This at first lies in the bicipital groove between the two tuberosities, penetrates the capsule, and passes through it, lined with a special process of synovial membrane, to its insertion already described upon the glenoid ligament, above the fossa. The peculiar nature of its course will be clear on examining Fig. 3526. Some of the fibres pass beyond the glenoid ligament and are attached directly to the bone.

By this peculiar course the tendon becomes one of the most efficient strengtheners of the articulation, acting precisely where force is needed, and holding down the bone against the glenoid fossa like a strap, preventing its displacement upward by the action of the deltoid and the muscles inserted into the tuberosities. It grooves the inner tuberosity more than the outer, thus tending to counteract the outward twist of the arm given by the insertion of the muscle upon the tuberosity of the radius (Humphry). Sudden muscular contraction has been known to pull it asunder, and this accident may at once be recognized by a prominent swelling on the front of the arm, caused by the tonic contraction of the muscular belly. In rare cases it has been torn from its seat in the groove, usually by direct violence. The groove can then usually be felt as empty; the humeral head is slightly elevated and rotated inward (White). In cases of dislocation of the humerus the tendon usually remains uninjured, but may be torn from its attachment or dragged from its normal situation. The head of the bone may pass between the two heads of the biceps, which may hold it and offer an obstacle to the reduction of the dislocation. In resection of the head the tendon is considerably in the way, and it is usual to detach it from its groove and hold it to one side. Tillaux holds that in these cases it is quite proper to cut it, if it at all embarrasses the operation, as it is almost certain to slough during the ensuing suppuration.

The varieties which occur in the biceps muscle have given rise to a careful investigation of its mode of origin. One of the most rare of these is shown in Fig. 3527. The biceps here has four heads, one of the supplementary ones arising from the capsule of the joint. Welcker has examined the behavior of the long head of the biceps in many animals, and finds that in some cases it is entirely superficial, separated from the capsule by a bursa. Between this and the usual condition all stages of penetration of the capsule are found. These are shown in Fig. 3529. The tendon first grooves it, then penetrates it, and lies between the ligament proper and the synovial membrane, then buries itself sideways in this, gradually acquiring a fold connecting it with the wall known as the mesotenon; then this is finally lost, the muscle passing freely through the joint invested by its own special sheath of synovial membrane, which becomes continuous with that lining the joint at either end. On investigating the stages of development in the human fœtus, we find a similar series of changes. The mesotenon of the fœtal joint is shown in Fig. 3528. It appears therefore probable that the capsular head shown in Fig. 3527 is merely a detached fascicle, left behind by the long tendon in its gradual penetration of the capsule.

FIG. 3528.—Shoulder-joint of a Fœtus Showing the Mesotenon of the Biceps. (Welcker.)

Some cases of absence of the long head of the biceps have been reported. While most of these are doubtless due to pathological causes, the tendon having been absorbed by inflammatory processes, there are yet some instances of congenital absence, the bicipital groove being empty and nearly obliterated, and there being no trace of a process of the synovial membrane corresponding to an atrophied tendon.

The synovial membrane of the joint is large, but it rarely becomes diseased. Indeed, it is freer from disorders than that of any other of the large joints of the body, owing probably to the general absence of any exciting causes. Two diverticula of the synovial sac are found, as already mentioned, one under the subscapularis, the second running down along the tendon into the bicipital groove. These are respectively called the *bursa scapularis* and *bursa intertubercularis* (see Fig. 3530). The opening of the subscapular bursa varies in size. Humphry states that the head of the humerus has been dislocated into it with but little apparent rupture of the capsule. The place where any effusion into the joint first becomes manifest is anteriorly, in the interspace between the deltoid and pectoralis major.

Immediately outside the capsule are situated a number of bursal sacs which do not usually communicate with the joint, but which alleviate the friction between the muscles immediately surrounding the capsule and

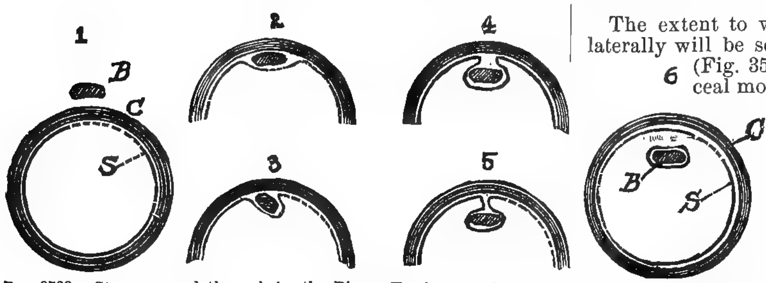

FIG. 3529.—Stages passed through by the Biceps Tendon, as shown by Specimens from Different Individuals. (Welcker.) *B*, Biceps tendon; *C*, capsule; *S*, synovial membrane.

those which lie more superficially. The most important of these is the *bursa subdeltoidea* (Fig. 3530), a large sac, usually double, that lies between the capsule and the structures arising

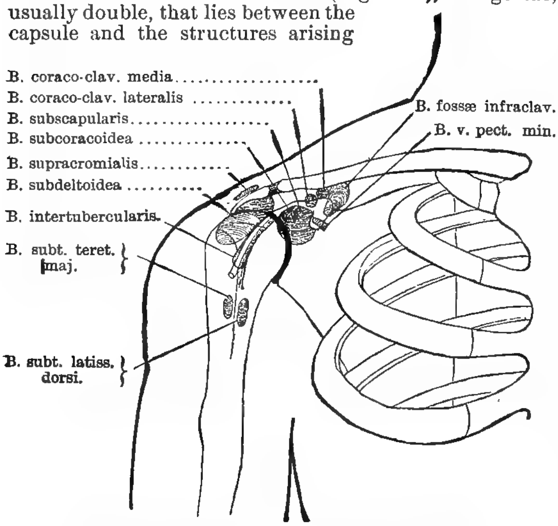

FIG. 3530.—The Principal Bursæ about the Shoulder.

from the acromion process, viz., the coraco-acromial ligament and the deltoid muscle. This may become in-

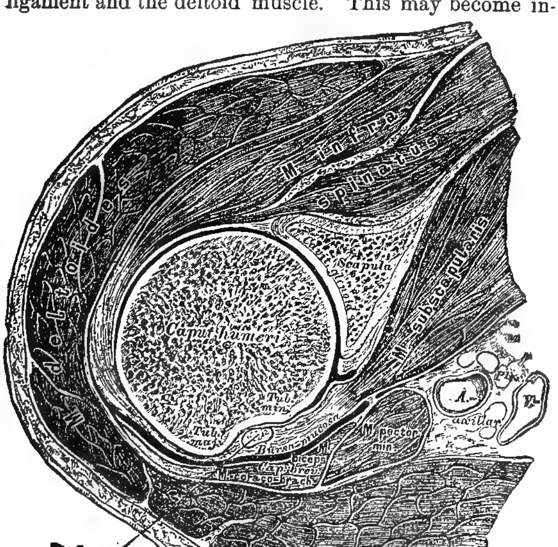

FIG. 3531.—Horizontal Section through the Right Shoulder. (Heitzmann.)

flamed or enlarged, and simulate an affection of the joint.

The extent to which the deltoid caps over the joint laterally will be seen on looking at a horizontal section (Fig. 3531). Its thick and strong fibres conceal most of the features of the joint, but yet the humeral head does make a considerable prominence externally, and whenever it leaves its socket a depression, easily recognized if taken before swelling sets in, can be noted just below the acromion process.

The deltoid is supplied by the circumflex nerve from the brachial plexus, and this also gives the main supply to the joint. The suprascapular and subscapular nerves also send twigs. One of the most frequent complications of a fracture of the surgical neck of the humerus is a paralysis of the deltoid, occasioned by an injury to this nerve where it winds around between the bone and the long head of the triceps. This is a serious difficulty, for the deltoid is the only muscle that can abduct the arm. The nerve must be carefully avoided in all resections of the head.

The arteries supplying the joint are all insignificant branches from the axillary and the subclavian, offering no real obstacle to the surgeon.

The movements possible to the joint consist of angular motion in all directions, the combining of these to form circumduction and rotation. Movement toward the anterior plane of the body is more free than that behind. The coracoid arch limits abduction beyond a right angle, to lift it higher the scapula must be tilted. Rotation is used to assist the pronation and supination of the fore-arm.

Frank Baker.

SIALAGOGUES (also written *Sialogogues*), agents which excite the flow of saliva. Agents producing this effect are naturally divided into two classes, viz., (1) those which act locally and directly, and (2) those which exert their influence upon the salivary glands secondarily, through the medium of the general circulation.

In the first class, termed *masticatories*, may be ranked all agents capable of directly exciting a flow of saliva when placed in the mouth or chewed, excluding, of course, mere alimentary substances. For practical purposes, however, the term is restricted to a limited number of articles, some of which have been employed for medicinal purposes, but most of them are used by the laity for stimulant or narcotic effect. Thus, among people of our own country, tobacco is largely employed as a masticatory, while in South America coca, and in India betel, are used in the same manner. These drugs placed in the mouth and slowly chewed excite a more or less abundant flow of saliva, in which is dissolved the active principles of the plant employed; and the saliva so impregnated being swallowed, or taken up by the absorbents of the mucous membrane of the buccal cavity, produces the effect desired, generally in a slow and continuous manner. But in the case of habitual tobacco-chewers the flow of saliva is, as a rule, excessive, and is commonly ejected from the mouth, the entire narcotic effect being produced through the medium of the absorbents of the buccal cavity.

Now, when we consider the important part played by the saliva in digestion, it appears evident that this excessive flow, nearly all of which is ejected, must be injurious. Still, this is but an incident compared with the narcotic effect of the drug which enters the circulation. And though in some instances the excessive flow of saliva becomes almost a systemic depletion, the more serious results of tobacco-chewing, as compared with tobacco-smoking, are due to the fact that a far greater amount of the drug enters the circulation in the former than in the latter way. This is partly due to the greater concentration of the active principles of the drug in the saliva of the chewer, and partly, also, to the fact that the chewer uses tobacco almost continuously during his waking hours, while the smoker indulges, as a rule, only at intervals.

Among the other masticatories handed down by the text-books from generation to generation are *pyrethrum*, *armoarcia*, and *mezereon*, but their medicinal use in this manner is long since obsolete.

The gum-resins of certain forest-trees, as the sweet-gum (*Liquidambar Styraciflua*), tamarack (*Larix Americana*), and black spruce (*Abies nigra*), are used as masticatories, particularly by women and children, but this habit is an offence against conventionality rather than hygiene. Indeed, gum-chewing, in some instances of feeble digestion, appears to be beneficial, whether by reason of the simple ingestion of saliva—for the gum is practically insoluble in this secretion—or because the individual's mind is diverted from his laboring stomach, it is not important to inquire.

This statement, however, is only applicable to the digestive period, for the pouring of an excessive amount of saliva into an empty stomach is not innocuous.

Turning from masticatories to sialagogues proper—those agents which excite a flow of saliva through the medium of the general circulation—we are struck by the contrast of their diminished number, for the drugs known to possess this property are very few. At the head of the list, until recently, has long stood mercury. Generations of medical men have employed mercury for the express purpose of increasing the salivary secretion, with the idea that in this manner the system of the patient was purified of morbific matter. This practice, begun as a cure for syphilis, rapidly extended until it ultimately became the standard routine treatment for nearly all diseases. Its history is, indeed, one of the curiosities of medical literature, as upon this property of mercury was based a pathological theory which long fettered the medical mind and effectually retarded scientific progress.

As the action of this drug is minutely discussed in another part of this work (see Mercury), it is only necessary here to observe that its use as a sialagogue is practically obsolete. That is to say, profuse salivation by mercury is, at the present day, considered a poisonous rather than a strictly medicinal effect, and it is therefore carefully guarded against. The interest, then, attached to mercury as a sialagogue is little more than historical.

Not so, however, with the next drug to claim our attention, namely, jaborandi. In jaborandi we have an agent which, in addition to a powerful influence upon the sweat-glands, also greatly stimulates those of the salivary apparatus. And this effect is not produced slowly, as is the case with mercury, nor for a great length of time. It follows quickly upon the administration of the drug, and is of short duration. Moreover, the flow of saliva produced by an efficient dose of jaborandi is so abundant as to amount to a positive depletion, often found of essential service, especially in cases of uræmic poisoning. Though the salivary glands are excited to a remarkable degree, this excitement is but transitory; and the inflammation and ulceration so commonly attendant upon mercurial salivation never result from the use of jaborandi. Unfortunately, however, jaborandi is a cardiac depressant, and on this account requires to be used with caution. It is, in fact, the only sialagogue properly entitled to the name, since it is the only agent which can be employed to excite the flow of saliva for remedial purposes. And even as a sialagogue it is much less valuable than as a diaphoretic. (See Jaborandi.)

A few other medicinal agents occasionally produce salivation as one of their effects, but as they are never used for this purpose their consideration may well be omitted.
Laurence Johnson.

SILICATES. The only use at present for the silicates is in surgery, in the preparation of immovable dressings for fractures, etc. For this purpose solutions of both the potassium and the sodium salts (called soluble glass) have been employed, but the latter is far preferable to the former, and should always be selected when possible.

The solution of Silicate of Sodium (*Liquor Sodii Silicatis*) is the only officinal preparation of the silicates. It is "a semitransparent, almost colorless, or yellowish, or pale greenish-yellow, viscid liquid, odorless, having a sharp saline and alkaline taste, and an alkaline reaction. The sp. gr. of the commercial solution is between 1.300 and 1.400. A drop of the solution, when held in a non-luminous flame, imparts to it an intense yellow color. If a portion of the solution, considerably diluted with water, be supersaturated with nitric acid, a gelatinous or pulverulent, white precipitate of silicic hydrate will be produced. A small quantity should not produce any caustic effect when applied to the skin (absence of an excessive amount of alkali)." For an account of the surgical uses of sodium silicate the reader is referred to the article Splints.

Silicate of sodium is said to possess anti-fermentative properties, and has occasionally been employed as an antiseptic by some French surgeons. Marc Sée has reported good results from its external use in chancre, and from urethral injections in gonorrhœa. Dubreuil injected it into the bladder, in a case of vesical paralysis occurring with hypertrophy of the prostate gland in an old man, and found that it prevented ammoniacal decomposition of the urine. The sodium and potassium salts have also been given internally in rheumatism. The medical uses of the salts are, however, obsolete, and as they have been shown to possess toxic properties in experiments upon dogs, it is probably just as well that their therapeutic employment should not be revived.

Hydrated magnesium silicate, the meerschaum from which pipes are made, has been suggested by Garraud as a substitute for bismuth subnitrate, which salt it resembles, in diarrhœa. Good results were reported from its use, but it did not appear to possess any advantages over the bismuth.
T. L. S.

SILURIAN SPRING. *Location and Post-office.*—Waukesha, Waukesha County, Wis.

Access.—From Chicago by the Chicago, Milwaukee & St. Paul, or the Chicago & Northwestern Railroads.

Analysis.—Professor W. S. Haines. One gallon contains:

	Grains.
Chloride of sodium	0.1926
Sulphate of sodium	0.2917
Bicarbonate of sodium	0.0301
Carbonate of calcium	9.9277
Carbonate of magnesium	6.8324
Carbonate of iron	0.1285
Phosphate of iron	traces
Phosphate of manganese	traces
Alumina	0.5827
Silica	0.7004
Organic matter	very faint trace
Total solids	18.6861
	Cub. in.
Carbonic acid gas	44.7

Therapeutic Properties.—This water is very similar in composition and effect to the Bethesda. It is mildly alkaline and saline, and, being perfectly free from organic matter, it acts freely as a diuretic and antacid. It is used with success in dyspepsias and kidney and mucous membrane diseases generally. This spring is situated in the southern part of Wisconsin, about twenty miles west of Milwaukee, on the Fox River, in the town of Waukesha. There are a number of good hotels in the village, which has a population of about thirty-five hundred. Within a distance of ten miles are several beautiful lakes, affording good fishing.
G. B. F.

SILVER. I. General Medicinal Properties of Compounds of Silver.—In medicinal dosage the most important effect that follows persistent internal medication with silver is the tendency to a bluish-black discoloration of the skin and mucous membranes. This staining shows first on the mucous membranes, so that by inspection of the inner surfaces of the lips and of the fauces, during a course of medication by silver, and by stoppage of the medicine upon the first beginning of a bluish discoloration of those parts, no serious risk of staining of the skin need be incurred. As a rule, efficient dosage with silver can be maintained for from one to three months before coloration begins. In overdosage silver is a constitutional poison, impairing nutrition generally, and

deranging the nervous system particularly. Therapeutically, impregnation of the system with silver tends to oppose, albeit feebly, the onward march of certain diseases of the nervous system, such as epilepsy and tabes dorsalis. But in the more intractable of these diseases, such as tabes, the influence is so slight as to be of no value—if, indeed, it exist at all—and in epilepsy other remedies are far more potent. The use of silver for constitutional effect is, therefore, in modern practice, seldom resorted to.

Locally, the effects of silver compounds differ with the individual preparations according to their solubility, and will be described in connection with the several compounds themselves.

II. The Medicinally used Compounds of Silver.—These comprise the several salts, *argentic oxide, iodide,* and *nitrate.* The *cyanide* is also officinal in the U. S. Pharmacopœia, but for pharmaceutical purpose only.

Argentic Oxide: Ag_2O. Argentic oxide is officinal in the U. S. Pharmacopœia as *Argenti Oxidum*, Oxide of Silver. It is "a heavy, dark brownish-black powder, liable to reduction by exposure to light, odorless, having a metallic taste, and imparting an alkaline reaction to water, in which it is very slightly soluble. It is insoluble in alcohol" (U. S. Ph.). This oxide readily yields its oxygen in presence of oxidizable matter, and hence should not be triturated with any such material. It dissolves in water of ammonia. From its comparative insolubility this compound has little local effect, but when swallowed, probably through chemical conversion, it is capable of absorption, and exerts the constitutional effects of silver, such as they are. In such operation the oxide is thought to be less prone to discolor the skin than the nitrate, but it is certainly not wholly innocent of this tendency. Upon the stomach and bowels silver oxide has quite a marked potency to allay irritability, tending to quell vomiting, even in such complaints as ulcer and cancer of the stomach, and to control diarrhœa when arising as a reflex of nervous irritation. The principal employment of the medicine is in such disorders of the digestive apparatus. The average dose is about 0.06 Gm. (one grain), best given in powder or capsule. The pill form is bad, because of the deoxidation of the compound by the organic matter of the excipient, which reaction may even be attended by explosion. Gum arabic is recommended as the least objectionable excipient.

Argentic Iodide: AgI. The salt is officinal in the U. S. Pharmacopœia as *Argenti Iodidum*, Iodide of Silver. It is "a heavy, amorphous, light-yellowish powder, unaltered by light if pure, but generally becoming somewhat greenish-yellow, without odor and taste, and insoluble in water, alcohol, diluted acids, or in solution of carbonate of ammonium. Soluble in about 2,500 parts of stronger water of ammonia" (U. S. Ph.). Argentic iodide is, medicinally, substantially a duplicate of the oxide, and may be used for the same purposes and in the same dose.

Argentic Nitrate: $AgNO_3$. This, by far the most important compound of silver, is officinal in the U. S. Pharmacopœia in three conditions, namely, in crystals, in cylindrical sticks moulded by fusion, and in similar sticks in admixture with equal parts of potassic nitrate.

Argenti Nitras, Nitrate of Silver. This title signifies the salt in crystals, which the Pharmacopœia describes thus: "Colorless, transparent, tabular rhombic crystals, becoming gray or grayish-black on exposure to light in presence of organic matter, odorless, having a bitter, caustic and strongly metallic taste and a neutral reaction. Soluble in 0.8 part of water and in 26 parts of alcohol at 15° C. (59° F.), in 0.1 part of boiling water, and in 5 parts of boiling alcohol. When heated to about 200° C. (392° F.), the salt fuses to a faintly yellow liquid, which, on cooling, congeals to a purely white, crystalline mass. At a higher temperature the salt is gradually decomposed, with evolution of nitrous vapors. It should be kept in dark amber-colored vials protected from the light." These crystals constitute the purest form of the nitrate, and are used for internal giving or for the making of solutions.

Argenti Nitras Fusus, Moulded Nitrate of Silver, "Fused Nitrate of Silver," "Lunar Caustic." The crystals are melted by heat, and the fused salt poured into moulds where it sets on cooling. But inasmuch as the pure nitrate is, when fused, inconveniently brittle, the Pharmacopœia provides for a trifling admixture of argentic chloride, which is a tough compound. To this end about four per cent. of hydrochloric acid is added to the melted crystals, whereby a small portion of the nitrate is converted into chloride. Reaction having ceased, the mixed mass is ready for moulding. Lunar caustic is cast in narrow cylindrical sticks, which are hard, brittle, and, when freshly made, white in color. As commonly found, however, they are gray, or even blackish, through chemical reaction with matters present in the atmosphere. "Soluble, with the exception of about five per cent. of chloride of silver, in 0.6 part of water and 25 parts of alcohol at 15° C. (59° F.), in 0.5 part of boiling water, and in 5 parts of boiling alcohol. It is insoluble in ether. Whatever is left undissolved by water is completely soluble in water of ammonia" (U. S. Ph.). Fused nitrate of silver should only be used for its legitimate purpose, that of external application.

Argenti Nitras Dilutus, Diluted Nitrate of Silver. Argentic and potassic nitrates, in equal proportion, are melted together by heat and the fused mass poured into moulds. The product is "a white, hard solid, generally in form of pencils or cones of a finely granular fracture, becoming gray or grayish-black on exposure to light in presence of organic matter, odorless, having a caustic, metallic taste, and a neutral reaction" (U. S. Ph.). The sticks dissolve freely in water and possess the same properties as the undiluted lunar caustic, only in milder degree. They are used only for local application.

Nitrate of silver differs from the oxide and iodide in the essential particular of free solubility, on which property depend the most valuable medicinal virtues of the salt. The most important reactions of the nitrate are that its solutions are precipitated by soluble chlorides to form the very insoluble salt, argentic chloride. This reaction is one of the most delicate in chemistry, and since traces of chlorides are present in almost all natural waters, the use of distilled water is necessary for solutions of nitrate of silver, if a clear, bright solution be desired. Nitrate of silver also reacts on organic matter generally, suffering decomposition, and forming, with the organic substance, compounds insoluble and acquiring a rusty brownish-black color under the action of light. Hence sticks of lunar caustic grow gray and black on the surface by keeping, by reaction with the organic dust of the atmosphere, and solutions of silver nitrate deposit a fine black sediment, and stain textile fabrics and skin. The stain on the skin, if recent, can be fairly well removed by rubbing with a moistened lump of potassic cyanide, and washing—always remembering the very irritant and poisonous character of such cyanide. But if the stain be old, and fixed by exposure to sunlight, the cyanide fails, and the following means may be resorted to: Moisten the stains, drop on them a little tincture of iodine, and then wash in a six per cent. solution of sodic hyposulphite. Or, very efficient, mix in a saucer a few bits of iodine with a little water of ammonia; rub the stains quickly with the resulting preparation, and immediately wash both skin and saucer while they are still wet. This latter precaution is necessary, since the compound of iodine and nitrogen produced by the mixture of chemicals spontaneously explodes upon slight agitation when dry. Other reactions of silver nitrate are its precipitation by sulphuric, hydrosulphuric, phosphoric, hydrochloric, and tartaric acids and their salts; by the alkalies and their carbonates, lime-water and the vegetable astringents, and arsenical and albuminous solutions.

Nitrate of silver is an irritant astringent, with also the peculiar specific effects of silver compounds already detailed, viz., the allaying of gastric irritability, and the induction of certain constitutional control over nervous disease. The local effects are the more important, and are as follows: The salt readily combines with albumin to make an insoluble compound, the albuminate of silver; hence, when in strong solution or in solid stick, its application to the surface of a mucous membrane or of granu-

lation-tissue produces a white streak of cauterization, which, by the insolubility of the compound formed, limits the action of the caustic to the production of such shallow slough. Concentrated applications to the skin speedily blacken the epidermis, and, more slowly, raise a blister. In solutions less than ten per cent. in strength the salt is hardly caustic, but acts only as an irritant astringent. When swallowed, quite small doses act locally like the oxide, while large produce irritant poisoning. Therapeutically, local applications of silver nitrate judiciously made have a marked tendency to promote absorption in such tissues as are capable of undergoing this process ; to induce healing ; to limit and abate the catarrhal process ; to destroy skin-parasites, though not very searchingly ; and to neutralize the virulence of specifically noxious pus.

The medicinal uses of silver nitrate are such as may be deduced from the foregoing. Internally the medicine may be given, for constitutional or local effect, in doses of from 0.015 to 0.03 Gm. (from about one-fourth to one-half grain) in pill or solution. In neither way of giving does the salt probably reach the stomach as nitrate ; for, if in solution, a medicinal dose must almost certainly be decomposed in the swallowing, and, if in pill, be acted on similarly by the necessary organic matter of the excipient. To obviate this effect as far as possible in the case of pills, it is advised that bread-crumb be particularly avoided as an excipient, because of its containing a soluble chloride (common salt) as well as organic matter, and that some vegetable extract, or a dry powder made sticky by a minimum of gum, be selected. In any case the crystallized silver salt should alone be prescribed. Externally, silver nitrate may be used as a caustic, but only where a superficial effect is wanted, as for the destruction of the lining membrane of a cyst. The fused stick is in such cases used, its moistened surface being swept over the surface to be destroyed. More common is the application to promote absorption, as in case of exuberant granulation-tissue or trachoma-bodies ; to determine healing, as in unhealthy ulcers ; or to shorten and abate the course of a catarrh. For such purposes various strengths of the nitrate are used, from application of the pure or diluted sticks of lunar caustic to that of solutions of not more than the one-fifth of one per cent. strength. To determine absorption the stronger applications are necessary, to control catarrhs the weaker; but in all cases care should be taken not to overdo the matter, and, by too strong or too frequent application, to actually interfere through excess of irritation with healing or with resolution. In the case of catarrhs, moreover, the remedy should not be used at all until the second stage of the process is reached, as betokened by the establishment of the catarrhal secretion and abatement of the initial pain or sensitiveness. Then, too, the strength of the application should be adjusted to the different degrees of sensibility of the different mucous membranes ; for while the comparatively insensitive membranes, such as those of the fauces or vagina, may take a five per cent. solution, or even stronger, hardly more than the one-tenth of this strength can be applied without undue irritation to the nasal passages or to the male urethra. When a very brief action is wanted, the application of silver may be immediately followed by one of a solution of common salt, which salt immediately precipitates all excess of nitrate as the insoluble, and therefore inert, compound, silver chloride.

Argentic Cyanide: AgCN. This salt is officinal in the U. S. Pharmacopœia as *Argenti Cyanidum*, Cyanide of Silver. It is a "white powder, permanent in dry air, but gradually turning brown by exposure to light, odorless and tasteless, and insoluble in water and in alcohol. Insoluble in cold, but soluble in boiling, nitric acid, with evolution of hydrocyanic acid ; also soluble in water of ammonia and in solution of hyposulphite of sodium. When strongly heated, the salt fuses, gives off cyanogen gas, and, on ignition, metallic silver is left" (U. S. Ph.). Argentic cyanide is not used in medicine, but only in pharmacy, for the making of diluted hydrocyanic acid.

Edward Curtis.

SILVER, POISONING BY. The most important salt of silver, medico-legally, is the nitrate, which is prepared by dissolving silver in dilute nitric acid. It crystallizes in transparent rhombic plates, and has an exceedingly acrid metallic taste. It is soluble in less than its weight of water at 59° F. (15° C.). Melting-point, 198° C. The melted salt run into moulds forms the officinal *Argenti Nitras Fusus* (lunar caustic). To overcome its brittleness, or to modify its action, the salt is sometimes fused with a certain proportion of silver chloride or potassium nitrate. Nitrate of silver, when pure, is not blackened by exposure to light ; but, when in contact with organic matter, it is decomposed, with formation of a black, insoluble compound. Hence its use in indelible inks. For the same reason living tissues to which the nitrate has been applied soon turn black. Hydrochloric acid or soluble chlorides produce in solutions of this salt a white, curdy precipitate (silver chloride), soon turning violet upon exposure to light, soluble in ammonium hydrate, insoluble in nitric acid. The nitrate is used in indelible inks, in hair-dyes, largely in chemical analysis and in photography, and in medicine, both externally and internally. Poisoning by nitrate of silver may be either acute or chronic.

Acute Poisoning.—This is rare, and is usually accidental, resulting from swallowing pieces of nitrate of silver pencils which have been broken off in the act of cauterizing the throat. Very rarely a solution has been taken accidentally or for suicidal purpose. The disagreeable taste of the salt is likely to frustrate any attempts to make use of it for criminal poisoning.

Symptoms.—Nitrate of silver is a violent irritant and corrosive. Large doses are followed, therefore, by symptoms of gastro-enteritis, namely, severe burning pains in the region of the stomach and intestines, violent vomiting, and diarrhœa. If the ordinary chemical antidote (common salt) has been administered, the vomitus and fæces may be white and curdy, becoming violet or nearly black upon exposure to light. This appearance, as well as the black stains upon those parts of the body with which the salt has come in contact, such as the lips, aid materially in making a diagnosis. The nitrate also acts upon the nervous system, producing loss of consciousness, convulsions, paralysis, and disturbances of respiration.

Fatal Dose—Fatal Period.—These are not determined. Death has followed the ingestion of 1.94 gram (30 grains). Taylor mentions the case of a woman who took 3.24 grams (50 grains) in divided doses, and died in three days. Recovery has taken place in two cases after the ingestion of 31.1 grams (℥ j.). Death has ensued as early as six and nine hours—children in both cases.

Post-mortem Appearances.—These, so far as observed, are similar to those characteristic of the irritant poisons in general, namely, redness and injection of the mucous membranes of the œsophagus, stomach, and intestines. White or grayish patches have been noticed in the stomach and duodenum.

Treatment.—Common salt and milk should be administered freely. Vomiting should then be induced ; for the chloride of silver is soluble in an excess of sodium chloride, and the albuminate is soluble in the digestive fluids. In other respects the treatment should be symptomatic.

Mode of Action.—It is reasonably certain that the nitrate undergoes decomposition as soon as it reaches the stomach. It forms, with hydrochloric acid and soluble chlorides—as sodium chloride—the chloride of silver. This is insoluble in water, but soluble in solution of sodium chloride. With albuminous matters it forms an albuminate, soluble in solution of sodium chloride and in the digestive fluids. It is probable that silver is absorbed in one of these forms, or in some similar form.

Rouget has shown, by experiments on animals, that the soluble salts of silver produce, first, vomiting and diarrhœa, soon followed by muscular weakness, paralysis, disturbances of respiration, and weak clonic convulsions. In cold-blooded animals their administration is quickly followed by severe tetanic convulsions, similar to those

produced by strychnine, then by disturbances of respiration and paralysis. Death is due to asphyxia. Two theories have been proposed in explanation of the asphyxia. One assumes that it is due to congestion of the lungs and to the excessive secretion of mucus in the lungs—such as has been observed in experiments on dogs and cats; the other that it is due to a direct action of the poison on the central nervous system (Charcot and Ball, Rouget, Curci). The results of Rouget's experiments on animals point to the latter as the more probable explanation. For, although finding respiratory symptoms prominent in all cases, only occasionally were any pulmonary lesions found after death. Curci considers the general paralysis a reflex paralysis. According to Falck the temperature sinks 44° to 63.7° F. (6.7° to 17.6° C.) after subcutaneous injection of the nitrate in rabbits.

CHRONIC POISONING—ARGYRIA.—The name argyria has been given to a condition which follows the long-continued use of nitrate of silver, and which is characterized by a gray discoloration of the skin, of greater or less intensity, the color being ordinarily deeper on those parts of the body which are exposed to the light. It is most frequently the result of the long-continued use of medicinal doses of the nitrate taken internally. Two cases are reported which were the result of its application to the throat, extending over some years, as a caustic, small quantities being swallowed and absorbed (Duguet); and a case is reported, the result of the use, for a number of years, of a solution of the nitrate for coloring the beard (Bresgen). Recent observations made on silver-plate workers in Berlin have shown that absorption of silver may follow constant handling, for a long time, of the metal, and that among such workers characteristic-colored patches, round or oval in shape, and varying in size from a millet-seed to a broad bean, are very frequent, occurring principally upon the dorsum of the left hand. The men affected were invariably those who had some ulceration or abrasion of the skin, through which the metal was probably absorbed.

The first symptom of argyria is usually an inflammatory swelling of the gums, with a blue or violet line at the junction of the gums with the teeth. If the administration of the silver compound is continued, there appear later, on various parts of the skin, grayish patches, which gradually increase in size; the whole skin, as well as the visible mucous membranes, finally presenting a grayish or grayish-black discoloration. This discoloration is not, however, limited to the skin and superficial mucous membranes, but may involve the internal organs and mucous membranes. It is more intense on those parts of the skin which have a thin epithelial covering. A local argyria may be produced by the frequent application, over a long period, of nitrate of silver to wounds of the surface of the body or mucous membranes.

The length of time and the amount of silver preparation requisite to produce the discoloration of the skin cannot be definitely stated. A general discoloration of the body is not likely to appear, so far as can be judged from recorded cases, till the lapse of a year or thereabout, or till as much as fifteen to thirty grams ($3\frac{3}{4}$ to $7\frac{1}{2}$ drachms) of the nitrate has been administered. Larger amounts have been taken, however, without producing any discoloration. It would seem that the suspension of the nitrate for a while has no certain effect in postponing the appearance of the discoloration when the administration is again resumed; for a case is reported in which the administration was resumed, after an interruption of six years, and was followed by discoloration in six months. The explanation is probably to be found in the failure of the system to eliminate to any great extent the silver which has once been absorbed. The line on the gums has been observed in two months, during which time 3.9 grams (60 grains) of nitrate of silver had been taken (Guipon).

The general health does not appear to suffer in argyria in man. Bogoslowsky, however, produced argyria in animals, and observed in them loss of appetite, diarrhœa, emaciation, albuminuria, followed by death.

Microscopic examination shows that the discoloration in argyria is due to the presence of minute black granules, probably metallic silver or some compound of silver (according to Krissinsky an organic compound of silver). In the skin they are found under the rete Malpighii in the superficial layers of the corium, in the deep connective tissue, in the sweat and sebaceous glands, in the smooth muscular fibre, and in the media and adventitia of the arteries. The epithelium is free. In the intestines the epithelium is also free from color, while the remaining parts are pigmented. In the internal organs the deposit is most noticeable in the smaller vessels and connective tissue. In the kidneys the glomeruli especially are pigmented. The substance of the brain and spinal cord is free, but in the choroid plexus the deposit is abundant. It is also especially abundant in the cells of the medulla of the bones (Krissinsky), the intima of the aorta and other large vessels, and in the mesenteric glands. Bogoslowsky in his experiments on animals found advanced fatty degeneration of the parenchymatous organs of the body, especially the liver and kidneys; and of the muscles, especially the muscular fibres of the heart.

The discoloration in argyria is permanent. No method of treatment is known by which it can be removed.

Absorption and Elimination of Silver.—Silver is absorbed and may be detected after death in the various organs of the body. The quantity taken into the circulation is probably very minute; the greater part of that taken into the stomach being removed with the fæces. Silver has been detected in the urine, and is probably eliminated chiefly through the kidneys. It is to be inferred from the permanency of the discoloration in argyria that elimination is very slow; that, in fact, in most cases, it is never completed. The pigmentation of the liver has been observed as late as five years after the cessation of a course of treatment with nitrate of silver.

Other Preparations of Silver.—Cyanide of silver and "silver solution," which consists of cyanide of silver dissolved in cyanide of potassium (the proportion of the latter very variable) are the only remaining preparations possessing medico-legal importance. The effects produced by these, so far as observed, do not differ materially from those produced by hydrocyanic acid, and it is probable that their poisonous action is due almost entirely to the acid. Reference is therefore made to the article on Poisoning by Hydrocyanic Acid. Nothing definite is known regarding the poisonous dose of either preparation. Death has occurred in ten minutes after swallowing fifteen cubic centimetres (ʒ iv.) of silver solution.

William B. Hills.

SKELETONS, PREPARATION OF. *General Directions.*—*a.* "If one can choose the specimen, a young adult should be selected. In too young animals the epiphyses are apt to separate easily from the diaphyses, and the symphyses open too easily. On the other hand, old animals sometimes have exostoses, or abnormal growths on their bones, and the sutures and symphyses are liable to be entirely obliterated."

b. If possible, a perfect skeleton of the part or parts under preparation should be before the operator, so that the exact position of delicate bones and processes may be seen, and hence not be lost or broken through inadvertence.

c. Careful notes should be made of the natural curves of the vertebral column, and of the position of the scapula, os hyoides, and in the lower animals of bones unconnected or but loosely connected with the rest of the skeleton. Measurements should be made of the length of the vertebral column and the thickness of the fibro-cartilage between two vertebral centra of each region at least. The thickness of the fibro-cartilage in the pelvic and other symphyses should also be determined, as also the thickness of the muscles separating the scapula from the ribs.

d. Whatever method is employed for the preparation of the bones, it is better to divide the animal, if it is large, into several parts by disarticulating some of the principal joints, as the humero-scapular, the femoro-innominate, the occipito-atlantal, and the other principal joints. The parts will then be more manageable.

e. The whole animal should bear a label, giving the name, date, sex, and, if possible, the age. Each separated part should have a label, giving the above general data, and also the name of the part. This is imperatively necessary with the vertebræ, the ribs, and the phalanges; hence, each must be labelled as it is separated from the rest of the body.

f. Parts like the pelvis and scapulæ, and the limb bones, exclusive of the manus and pes, which cannot be mistaken, may be put together and labelled as for the whole animal. Parts that might be difficult to distinguish should be kept in separate dishes and each properly labelled. The vertebræ might be divided into sets—cervical, thoracic, lumbar, etc.—and then connected by attaching a manilla string to a wire and passing it through the neural canal and tying the ends. The order of the bones cannot then be changed as they separate on the removal of the soft parts.

The ribs of one side, at least, should be removed one by one, and tied in order on a string or put into separate dishes. The phalanges of each hand and foot, commencing with the thumb and great toe, should be tied in order on a manilla string, then they and the other bones of each hand or foot may be very conveniently kept in a small sack made of cheese-cloth. Sesamoid bones would be best preserved in separate sacks or vials, each one having its own label.

In some of the lower animals the so-called splanchnic bones, *i.e.*, bony parts of organs, like the heart in the ox, diaphragmatic bone of the hedgehog, bone of the penis in the cat, raccoon, etc., must be removed from the animal before the cleaning commences, or the organs are removed and thrown away. If these are to form part of the prepared skeleton, it is essential to determine accurately their relative position on the fresh animal as they are removed.

g. Bones of different animals should not be put into the same dish, unless they differ so greatly in size or conformation that confusion would be impossible.

Finally, it is unnecessary to bore holes in the bones in order to allow the interior soft parts to escape or be removed, as is often recommended, for the natural canals in a bone render it somewhat like a sieve or sponge, and give sufficient communication between the interior and exterior.

Artificial and Natural Skeletons, and Methods of Preparation.—When all of the soft parts of the body are removed in any way, most of the bones fall apart, and if they are to be arranged and held in their natural relations, they must be connected artificially by wires, strings, bolts, etc.; hence the name *artificial skeleton*, in contradistinction to a *natural skeleton*, in which the natural ligaments or fibro-cartilages are left to hold the bones in position.

Whether the skeletons are to be natural, artificial, or simply kept as separate bones (so-called disarticulated skeletons), there are four principal methods of removing the soft parts:

1. *Putrefactive Maceration in Water*.—For this, stoneware, porcelain, or glass dishes, or zinc-lined tanks are employed, to avoid discoloration of the bones. The various parts of the animal, prepared as described in the general directions, are placed in separate dishes, and covered completely with clean, preferably soft, water. The dishes should then be placed in a room where the temperature does not fall below 18° to 20° C. (64.4° to 68° F.). If the room is still warmer the maceration will proceed all the more rapidly. The water should be changed frequently at first, *i.e.*, every day or every other day, if possible, for the first ten days or two weeks, then occasionally until the maceration is as complete as desired. By macerating in a warm room, and changing the water as directed above, discoloration of the bones and the formation of *adipocire* are almost always avoided. According to Morel and Duval, experience has shown that the placing of bodies in running water is not so good a method of maceration as that described above; there is, also, far greater danger of losing some of the bones.

During maceration the bones should be examined occasionally, and, if a natural skeleton is desired, the bones must be removed as soon as the muscles have decayed. If the bones are to be entirely freed from soft parts the maceration should be allowed to continue till these have completely decayed, or until they may be readily removed by a brush or a dull but smooth-edged knife. When sufficiently freed from their adherent soft parts the bones are rinsed with water and placed on clean paper or wood, to dry, each bone or set of bones being always accompanied by the proper label. The vertebræ, ribs, etc., may remain tied on a string, or they may be numbered. The bones of the hand and foot, and other small bones, are very conveniently kept in small cloth sacks.

It requires from two weeks to several months for complete maceration of a skeleton. The bones of small animals, and the young of the larger ones, macerate much more rapidly than those of large adult animals. Dissecting-room bodies that have been preserved by antiseptic injections macerate with great slowness. Frequent changes in the water, especially at the beginning, are necessary in order to wash away the preservative, which prevents the action of the putrefactive bacteria. It may be necessary to boil the bones of such subjects to remove most of the soft parts, using the macerating method only to finish the cleaning process.

2. *Boiling in Water alone, or in Water to which has been added some Chemical Substance*.—The animal is prepared and all the precautions taken as described under the general directions, then the bones are soaked a day or more in cold water, to dissolve out the coloring matter of the blood. They are then boiled in water, changing the water once or twice, until the soft parts are so far softened that they may be completely removed if an artificial skeleton is desired, or all removed but the ligaments and the fibro-cartilage, if a natural skeleton is to be prepared. Bones boiled in plain water are liable to be "greased," as it is called, that is, the melted fat penetrates the bones and makes them appear as if they had been soaked in oil. To avoid this, and also to hasten the disintegration of the soft parts, some saponifying substance is often added during the last half of the boiling. The following has proved quite satisfactory: After soaking the bones in cold water, and then boiling in plain water, about half as long as described above, they are boiled in the following mixture, diluted with an equal volume of water: Best soap, 75 grams; nitrate of potash, 12 grams; strong water of ammonia, 150 c.c; water, 2,000 c.c.

After the bones are cleaned by the boiling process they are rinsed and spread out to dry, as described for the macerated bones.

Boiling and the use of the saponifying substance have the advantage of being far less disagreeable than the macerating process. It is also much more rapid. For small animals, in which the bones are very dense, this method is entirely unobjectionable; but for man and the larger animals, generally, the ligaments, periosteum, etc., are so tough and thick that the boiling must be continued so long to soften them that the organic base of the bones is partly gelatinized and dissolved out, thus leaving the bones too brittle.

Preparation of Skulls.—The skull should be separated from the body, and if only the skull is to be preserved it is well to keep with it the atlas and axis. The eyes, skin, and most of the muscles are removed; the brain is broken up with a stick or metal instrument, and washed out with a syringe or strong stream from the tap; the larynx and os hyoides are removed together from the rest of the skull, and a natural skeleton made, leaving the larynx in its natural relations with the os hyoides. It is unsafe to macerate or boil the os hyoides and larynx, and a natural skeleton should be made by scraping (see below) the fresh specimen, or after preservation in twenty-five to thirty per cent. alcohol.

The skull may be boiled or macerated. Maceration is preferable for all but the smaller skulls. It is well to macerate the smaller skulls, even after they are cleaned so far as possible by boiling, in order to remove the soft parts covering the turbinated bones. To prevent the teeth from falling out it is well to disarticulate the man-

dible (inferior maxilla) and place the skull and the mandible, with the teeth uppermost, in the macerating dish; then they are held in place by gravity. The cleaning must be done with great care, to avoid breaking delicate processes and injuring delicate bones. Pieces of wood of various sizes and shapes are excellent for removing the softened muscles. etc.

Cements for Bones and Teeth.—The pelvis and mandible often separate at their symphyses, and the teeth may become loose and be in danger of falling out. This is especially liable to occur with macerated skulls. To unite separated or broken bones one may use glue, proceeding as for gluing wood; or the white-zinc cement used by histologists for sealing microscopical preparations may be used. If weight or traction is to be brought to bear on the connected parts they must be wired also. For fastening teeth in their sockets either of the above cements may be used, or plaster-of-Paris for large animals, or silicate of soda or potassa (liquid glass) mixed to a paste with powdered chalk. This hardens quickly, therefore it, as well as the plaster-of-Paris, must be used soon after preparation. The silicate cement and the glue are softened by water, and the white zinc is softened by the benzine used in degreasing. (See below.)

As soon as a macerated skull is rinsed, the teeth that are loose should be taken out one by one, the socket partly filled with one of the cements and then the tooth replanted. In this way the teeth may be kept in their proper places, and as the skull dries the teeth will be firmly fixed. Although the teeth of a boiled skull may be loose while it is moist, the gelatinized dental periosteum will usually fasten them very firmly as the skull dries. The teeth may, if necessary, be cemented as directed for macerated skulls.*

3. *Cutting and Scraping the Soft Parts from the Bones of Fresh, Dried, or Preserved Specimens.*—Fresh, dried, or preserved specimens may have the skeleton cleaned by simply cutting and scraping away the soft parts. It is necessary to work with great care, otherwise delicate processes and thin bones will be injured in removing the tough connective tissue. When the bones are cleaned as well as possible they are allowed to dry, when they may be degreased and bleached as described below.

The safest way to prepare the sternum, with its costal cartilages, the os hyoides, in connection with the larynx, is to prepare them fresh as just described, or, after preservation, in thirty to forty per cent. alcohol, if they cannot be freshly prepared. Cutting and scraping the flesh from the bones of minute animals, either in the fresh condition or after preservation in alcohol, is probably the only safe method. It is an especially valuable method for the preparation of natural skeletons of small and medium-sized animals, and of parts, as the sternum, of larger animals.

4. *Allowing Insects (Ants, Dermestes, Wasps), Tadpoles, or Sea-animals, to Eat away the Soft Parts of Fresh Specimens.*—It is desirable to remove the skin and most of the soft parts as for maceration or boiling; then, if dermestes are to be utilized, the partly cleaned skeleton is left in a damp room. The dermestes will find them, and the larvæ of these beetles will eat away the soft parts. If the aid of ants is to be sought, the partially cleaned bones are put in a box, with several holes in it, and placed near an ant-hill, and sugar sprinkled along the ground and on the bones. The ants will clean the bones more satisfactorily than the dermestes. It usually takes about a week for them to clean a cat's arm. Part of a fresh animal may be hung by a wasps' nest; they are said to clean it quickly and well. If tadpoles or sea-animals are to be utilized, the fresh specimen should be sunk in water in which the proper animals are known to be present. These methods are unsatisfactory. Only small animals or small parts of large animals will be cleaned by wasps or ants, and the dermestes only aid decomposition in the air, and the bones are very dirty and offensive after their action. In utilizing water-animals there is great risk of losing small bones. As a general remark it may be stated that a really good skeleton, perfect in all its parts, can be obtained only by a great amount of care, knowledge, and skill.

Preparation of the Bones of Young Animals.—Great care is necessary in this, on account of the readiness with which the epiphyses separate and the bones of the skull fall apart. The maceration or boiling should proceed only about as far as in preparing natural skeletons, the rest of the cleaning being done by careful scraping and cutting. As the boiling process is so rapid, it is perhaps safest, as the specimen is then constantly under the eye of the preparator.

Disarticulating Skulls.—A young or barely mature animal should be chosen, since the cranial sutures are liable to be partly or wholly obliterated in adults and the old. The skull may be cleaned by maceration or boiling. If the boiling process is used, boil the skull half an hour longer than for one not to be disarticulated. While still moist, the bones may be separated by steady traction and careful prying and wedging. This may be done with great readiness if half-grown animals are used. Skulls that have dried are usually more easily disarticulated after being soaked in cold or warm water until the remnant of connective tissue between the sutures has become softened. For a human skull to be disarticulated, that of a person from fifteen to eighteen years is best. It can be best cleaned by very complete maceration; then, while it is still moist, or after it has been remoistened, the bones are separated by traction, by wedging and prying, as described above. It is best to commence with the bones of the face, so that the larger and firmer bones may serve as a kind of handle, and also as a support. The disarticulation of skulls, except those of young animals, is very tedious, and requires a great deal of time and skill.

Degreasing Bones.—Except in rare cases neither does all the fat decompose in maceration, nor is it all saponified in the boiling process, hence it is necessary to use some solvent of fat to remove what remains. This solvent should not injure the bones, and it should be cheap. Benzine answers these requirements. After the bones have been cleaned in any of the ways described above, and thoroughly dried, they are placed in large glass jars or other vessels that can be tightly closed, and covered with benzine. If the bones are very greasy, it may be necessary to change the benzine once or twice. The time required for the degreasing depends on the size of the bones and the amount of grease in them. Two weeks is usually sufficiently long for a human skeleton.

Natural skeletons may be degreased by the benzine, but they must not be left too long in it, for it makes the ligaments, especially of boiled skeletons, too fragile.

Bleaching Bones.—If care be taken in changing the water during the first few days of maceration so as to remove all the blood, also if the blood be soaked out before boiling, the bones usually require no bleaching.*

If for any reason the bones are not sufficiently white they may be bleached after being well degreased: (*a*) By exposure to the sun, rain, and dew. This requires considerable time and a protected place. (*b*) The bones may be soaked in a weak solution of chloride of lime—chloride of lime, 2½ grams; water, 100 cc.—Labarraque's solution or eau de Javelle, 1 part to 4 or 5 of water. Chlorine is the bleaching agent in all of these, and the hydrochloric acid formed in the chemical reactions remains in the liquid and injures the bones, hence the necessity of a weak solution and a short exposure (4 to 12 hours). After the bones have become sufficiently bleached,

* "So far as concerns the general aspect of the skull, the incisors may be interchanged, and missing teeth may be replaced by teeth from other skulls. It is to be feared that such substitutions are sometimes made with skulls prepared for sale. Unless the changes are carefully specified such skulls have no real scientific value as regards the teeth." The same may be said of skeletons in general, in which several are put into the same macerating or boiling tank, and then the completely separated bones selected out and put together, or incomplete skeletons are completed by borrowing bones from another animal of the same or an allied species.

* If one has the specimen to be skeletonized in a fresh condition, it usually repays the trouble to wash out the blood by injecting a large amount of water into the blood-vessels. The arch of the aorta might be injected until the water runs uncolored from the veins. A constant-pressure apparatus is very convenient for this.

they are washed and dried. It is often advantageous to give the bones several short immersions, allowing them to dry in each interim, rather than one long immersion. Great care is necessary in bleaching natural skeletons with any of the chlorine compounds. (c) Degreased bones are quickly bleached by peroxide of hydrogen ($H_2 O_2$.). A so-called twelve to fifteen volume per cent. solution, diluted with an equal volume of water, and rendered neutral or slightly alkaline by the addition of ammonia or carbonate of soda, etc., will bleach a human skeleton in a few days. The bones must be put into a jar, and then covered with the peroxide solution, and tightly closed to prevent the escape of the oxygen. It is well to remove the bones and allow them to partly dry once or twice, to hasten the bleaching. The stock solution of peroxide should be kept in a cool place, and tightly corked, to prevent deterioration. Peroxide is the best bleaching agent for bones, as no injurious product is formed during the bleaching process. It is, however, expensive.

Final Arrangement of Skeletons.—If the skeleton is to be a disarticulated one, that is, if the bones are to remain separate, it is desirable to have each skeleton in one box, having the smaller bones in sacks or small boxes. The articulation or joining of the bones to make an artificial skeleton is a purely mechanical process, although it requires skill and experience. It can best be learned by working with an experienced workman. Rule of thumb should, however, be checked by careful observation of the natural attitude of the body and its curves, also the actual position of such movable parts as the scapula in the various positions in which it is desirable to mount skeletons. This can be done only on the living model.

A good general rule to follow in articulating a skeleton is to bore all necessary holes before attempting to put the bones of a part together. In this way strain on the partly mounted skeleton, and the necessity of boring holes in inconvenient positions, will be avoided. It is desirable to have diagrams of the various parts, showing the exact number and position of all wires and bolts. For study, and also for guidance in mounting, a hand and foot, with the bones held in apposition with spiral springs, instead of the wires ordinarily used, are very convenient, as the bones can be sufficiently separated to bring the articulating surfaces into view.

For natural skeletons the various parts should be arranged as desired while the skeleton is moist. If the parts are held in position by strings, pins, etc., they will dry and remain in the desired position. It is a great advantage to have a natural skeleton somewhat flexible. This may be attained by soaking the skeleton before it has been dried, or after remoistening it, in *Wickersheimer's preservative,** for three to ten days before it is arranged and dried. It is an excellent plan for small and young animals to have the hyoid, sternum, and tail prepared as flexible natural skeletons ; it is also desirable in many cases to have the hand and foot (manus and pes) of one side prepared as a flexible natural skeleton, although the rest of the skeleton is artificial.

The statements and directions in the present article are based upon personal experience in the Anatomical Department of Cornell University, upon the manuscript notes of Dr. Theobald Smith, and upon the works and papers named below.

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Simon H. Gage.

* This solution is prepared as follows: Arsenious acid, 16 grams ; sodium chloride, 80 grams ; potassium sulphate, 200 grams ; potassium nitrate, 25 grams ; potassium carbonate, 20 grams, are dissolved in 10 litres of boiling water. After cooling, the solution is filtered, and to it is added 4 litres of glycerin and 750 c.c. of ninety-five per cent. alcohol. For the purposes of preparing flexible natural skeletons the alcohol is unnecessary.

SKIN, ATROPHY OF THE. Synonym: Atrophia cutis propria. Atrophy of the skin may occur as a sequence of certain well-defined cutaneous diseases which produce ulceration or absorption of tissue, such as syphilis, lupus, or favus. It is also observed to follow and depend upon certain injuries of nerve-trunks, forming the glossy skin of Paget and Mitchell. But neither of these two conditions is a true idiopathic atrophy, and they will, therefore, not be considered in the present article.

Four forms or conditions of primary or idiopathic atrophy of the skin may be noticed, viz., atrophia cutis generalis, senilis, linearis, and maculosa.

1. *Atrophia Cutis Generalis.* — General or extensive atrophy of the skin is very seldom met with, although it is recognized by authors, and instances of it are occasionally reported. Many of these cases, however, belong more properly to xeroderma, morphœa, and scleroderma. In those cases of unilateral atrophy of the face in which the skin appears drawn down and atrophied, the lesion is deeper and involves the subcutaneous tissues, muscles, and occasionally even the bone. These cases, therefore, should rather be excluded here, as they are due to deep nerve influence—possibly, as has been suggested, to permanent irritation of the cervical sympathetic.

2. *Atrophia Cutis Senilis.*—Senile atrophy of the skin is to be looked upon as a physiological rather than a pathological condition, although the changes which take place with advancing years are such as predispose to certain diseases, notably pruritus senilis, and epithelioma. The skin of elderly persons loses its elasticity, the surface becomes dry and wrinkled, and the hue changes from the well-known flesh-color to more nearly the appearance of parchment, with a tendency to the formation of pigment points and to slight desquamation. The anatomical alterations upon which these changes depend consist in an atrophy of all the component parts of the skin and subcutaneous tissue, expressed in a thinned epidermis, flattened papillæ, shrunken corium, and atrophied hair-follicles, either with or without fine lanugo hairs ; the sebaceous glands have lost their activity, and are often found filled with dried epidermal masses. Another condition or form of atrophy is also described, in which the tissues undergo degeneration into a more or less homogeneous mass, styled hyaloid or waxy degeneration, or they may become granular and pigmented.

3. *Atrophia Cutis Linearis.*—Synonyms: Striæ atrophicæ ; Atrophic lines. These consist in lines or streaks in the skin, of various dimensions, of an inch or more in length by half an inch in width ; they are seen to be sharply defined in the healthy skin, slightly depressed, have a whitish or bluish-gray color, and give to the touch a sensation of being perceptibly thinned. When pinched up the surface presents fine wrinkles, very different from those in the adjacent skin. The most common and well-recognized form of this alteration is seen on the abdomen and breasts of women who have borne children, where the surface is more or less thickly covered with these striations (lineæ albicantes). They occur, however, in many other conditions and situations as well, and may appear wherever the skin has been subjected to somewhat rapid stretching, as on parts which have been anasarcous ; also where there has been sudden increase and diminution in flesh ; they are seen principally on the thighs and buttocks. The streaks are usually more or less parallel to one another, and commonly parallel to the long axis of the body. Microscopically these patches show atrophy of the textures of the skin, thinned epidermis, an almost entire absence of papillæ, and the connective tissue and elastic fibres of the corium are gathered into very thin bundles, with a few slender blood-vessels between them.

4. *Atrophia Cutis Maculosa.*—Synonyms: Maculæ atro-

phicæ: Atrophic spots. This most curious condition is quite rare, but is occasionally met with in very marked form. It consists in well-defined spots, from an eighth to half an inch or more in their longest diameter, generally roundish or oval, slightly depressed, whitish, smooth, and glistening, and suggestive of a very supple scar. Often but few will be seen, but occasionally several dozen may be observed scattered over various regions of the body. It is stated that these patches first manifest themselves as erythematous spots, and it is suggested that the condition is closely allied to morphœa, although there is none of the lardaceous deposit preceding the atrophy, such as is seen in the latter disease. No cause for the affection has been discovered.

The conditions here described are not such as generally call for treatment, and little or nothing can be done to affect them favorably. Local faradization and stimulants externally may arrest the increase of the linear and macular varieties. *L. Duncan Bulkley.*

SKIN DISEASES, CLASSIFICATION OF. The oldest forms of dermatological classification were based upon the seat of the affection, *e.g.*, diseases of the scalp and diseases of the rest of the surface. Later, skin diseases were divided into the local or idiopathic, and the constitutional, general, or symptomatic. "Unfortunately, not only may the same cutaneous affection be produced by the most different causes, but the most varied diseases of the skin may also be caused by one and the same morbid agent. And it is not possible in every instance to draw, from the form and appearance of a dermatosis, any certain inference as to its origin from a local or general cause" (Hebra).

Erasmus Wilson and others adopted an anatomico-physiological system, starting from the opinion that it is possible to ascribe distinct names and characters to the affections of the different tissues which make up the skin; that is to say, of the epidermis, of the rete, of the papillæ, of the corium, and of the follicles, the vessels, the nerves, etc. But the integument is an organ of which the component tissues are very rarely separately affected by disease, so that it is very often impossible to say which strata are more, and which less, involved. Systems of this sort have been found so peculiarly unpractical that they have never found many adherents.

The most popular classifications of skin disease in the past have been those which have for their basis the external form of the disease. The most important of these classifications was that of Willan, which included all cutaneous affections under the several heads of: 1, Pimples; 2, scales; 3, rashes; 4, vesicles; 5, pustules; 6, tubercles; 7, spots. At first sight this arrangement seems almost fascinating in its simplicity. But a single character is not enough for the determination of a disease, especially when thus torn from its connection with the other symptoms with which it is associated, and when all other appearances presenting themselves in the course of the case are left unnoted. Perhaps no other one thing, unless it be the eccentric and singular nomenclature devised by one or two great writers, has so hindered the study of diseases of the skin as this apparently simple classification.

The system, however, which for many years, and until quite recently, has dominated the German and American schools of dermatology, is that of Hebra. Less imposing perhaps than others which pretended greatly to scientific accuracy and logicalness, or which assumed the airs of a "natural system," Hebra's system has been found practically useful, and it is only of late years, with the great advance made in the clinical and pathological study of diseases of the skin, that this system has begun to prove cramping and insufficient. As modified slightly by the American Dermatological Association, and still used by it as the official framework for its valuable annual statistics of dermatology, this classification is as follows: Class 1, *Disorders of the glands;* class 2, *inflammations;* class 3, *hæmorrhages;* class 4, *hypertrophies;* class 5, *atrophies;* class 6, *new growths;* class 7, *neuroses;* class 8, *parasitic affections.*

In 1881 the late Professor Auspitz, of Vienna, put forth a system of classification more suitable to our present knowledge and needs than any one previously in use. As it cannot be clearly comprehended without the entire series of subdivisions, the whole scheme, excepting only the names of the specific affections, is given below:

FIRST CLASS.

Simple Inflammatory Processes of the Skin (Dermatitides Simplices).

A. Superficial Inflammations of the Skin.

(Dermatitides Catarrhales, Catarrhs of the Skin.)

I. Family: *Superficial Catarrhs of the Skin.*

1. Mere hyperæmia prevailing.
2. Sero-purulent exudation prevailing.

II. Family: *Erosive Catarrhs of the Skin (Stigmatoses).*

1. Due to animal parasites:
   Parasitic stigmatoses.
   (a) Entomoses.
   (b) Acarinoses.
2. Due to wounds of other kinds:
   Traumatic stigmatoses.

III. Family: *Follicular Catarrhs of the Skin (Perifolliculoses).*

1. Only around the apertures of the follicles.
2. Also around the excretory ducts of the follicle and the follicle itself.
   (a) Without simultaneous disease of the hair-sheaths and hairs.
   (b) With simultaneous disease of the hair-sheaths and hairs.

IV. Family: *Stasis Catarrhs of the Skin.*

1. With the termination of the formation of epidermis.
2. With the termination of cicatrization.

B. Deep-seated Inflammations of the Skin.

(Dermatitides Phlegmonosæ, Phlegmons of the Skin.)

I. Family: *Diffuse Phlegmons of the Skin.*

1. Due to burning.
2. Due to freezing.
3. Without external wounding.

II. Family: *Circumscribed Phlegmons of the Skin.*

III. Family: *Stasis Phlegmons of the Skin.*

SECOND CLASS.

Angioneurotic Dermatoses.

Dermatoses with the character of an extended disturbance of the tonicity of the vessels, together with more or less marked inflammatory congestion on the surface of the skin.

I. Family: *Infectious Angioneuroses of the Skin (Acute Exanthemata, Eruptive Fevers).*

1. With prevailing catarrhal character.
2. With prevailing phlegmonous (diphtheritic) character of inflammation of the skin.

II. Family: *Toxic Angiomata of the Skin (Medicinal Exanthemata).*

1. With prevailing inflammatory congestion.
2. With prevailing spasm of the vessels of the skin.
3. With obstruction of the vessels and termination in necrosis.

III. Family: *Essential (Idiopathic, Diathetic) Angioneuroses of the Skin.*

1. With prevailing inflammatory congestion.
2. With prevailing spasm of the vessels of the skin.
3. With dilatation of the vessels, and new growth of vessels.

THIRD CLASS.

Neuritic Dermatoses.

Due to diseases of the sensory (and also trophic ?) nerve elements.

I. Family : *Neuritic Dermatoses with Determinate Course.*

II. Family : *Neuritic Dermatoses with Indeterminate Course.*

1. With prevailing inflammatory congestion (neuritic inflammatory processes in the skin).
2. With prevailing spasm of the vessels of the skin (neuritic œdema of the skin).
3. With prevailing atrophy of the skin (neuritic atrophies of the skin).
4. With actual necrosis of the skin (neuritic necrosis of the skin).

FOURTH CLASS.

Stasis Dermatoses.

Dermatoses with the character of passive circulatory disturbance and injurious vaso-lymphatic absorption.

A. With Incomplete Stasis.

I. Family : *Hyperæmic and Anæmic Stases.*

II. Family : *Transudation Stases.*

1. The transudation remains in fluid form.
2. The transudation leads to induration and hypertrophy of the connective tissue of the skin.
3. The transudation leads to atrophy of the connective tissue of the skin.

B. With Complete Stasis.

Only Family : *Necrotic Stasis.*

FIFTH CLASS.

Hæmorrhagic Dermatoses.

Dermatoses resulting from increased passage of the red blood-corpuscles through the walls of the cutaneous vessels, without inflammatory congestion or local stasis in the latter.

I. Family : *Traumatic Hæmorrhages.*

II. Family : *Essential Hæmorrhages (i.e., Independent of External Irritation).*

1. With the existence of slight general disturbance.
2. With predominant general disturbance.

SIXTH CLASS.

Functional anomalies of the nerves of the skin without trophic changes of the skin.

A. Sensory Neuroses of the Skin.

I. Family : *Tactile Neuroses.*

II. Family : *Neuroses of Cutaneous General Sensation* (Dermatalgia).

1. The neurosis occurs in the form of pain.
2. The neurosis occurs in the form of itching.

B. Simple Motor Neuroses of the Skin.

Only Family : *Dermatospasmus.*

SEVENTH CLASS.

Anomalies of growth of the epidermis and its appendages.

A. Anomalies of the Epidermis and Secretion (Keratonoses).

FIRST ORDER.—Keratoses in a Narrower Sense.

I. Family : *Hyperkeratoses.*

1. Diffuse.
2. Around the follicle.
3. In areas, but independent of the follicles.

II. Family : *Parakeratoses.*

1. Diffuse.
2. Follicular.

III. Family : *Keratolysès.*

SECOND ORDER.—Trichoses.

I. Family : *Hypertrichoses.*

II. Family : *Paratrichoses.*

III. Family : *Atrichoses.*

1. Diffuse.
2. In areas.

THIRD ORDER.—Onychoses.

I. Family : *Hyperonychoses.*

II. Family : *Paronychoses.*

III. Family : *Onycholyses.*

FOURTH ORDER.—Steatoses.

I. Family : *Hypersteatoses.*

II. Family : *Parasteatoses.*

III. Family : *Asteatoses.*

FIFTH ORDER.—Idroses.

I. Family : *Hyperidroses.*

II. Family : *Paridroses.*

III. Family : *Anidroses.*

B. Anomalies of Pigment Formation in the Skin (Chromatoses).

I. Family : *Hyperchromatoses.*

1. Congenital.
2. Acquired.

II. Family : *Parachromatoses.*

III. Family : *Achromatoses.*

1. Congenital.
2. Acquired.

C. Anomalies of the Prickle-cell Layer of the Epidermis (Akanthoses).

I. Family : *Hyperakanthoses.*

1. Proliferation of the prickle-cell layer on the surface of the skin (warty akanthomata).
2. Proliferation of glandular ducts (cutaneous adenoma).

II. Family : *Parakanthoses.*

1. With distinct cornification of the newly-formed cells.
2. Without cornification of the newly-formed cells.

III. Family : *Akantholyses.*

EIGHTH CLASS.

Chorioblastoses.

Anomalies of growth of the corium and of the subcutaneous connective tissue.

A. Excessive Development of the Connective-tissue Layer.

Only Family : *Hyperdesmoses.*

B. Paratypical Growth of the Connective-tissue Layer of the Skin (Paradesmoses).

I. Family : *Granulomas of the Skin.*

II. Family : *Desmomas of the Skin.*

C. Atrophy of the Connective-tissue Layer, or Congenital Deficient Development of the Same.

Single Family : *Adesmoses.*

1. Universal and diffuse.
2. Partial.

NINTH CLASS.

Dermatomycoses.

Fungous diseases of the skin and its appendages.

I. Family : *Mycosis Scutulata.*

II. Family : *Mycosis Circinata.*

III. Family : *Mycosis Pustulosa.*

IV. Family : *Mycosis Furfuracea.*

Auspitz's method in the construction of his classes has been to regard, first the sum total of the processes upon which the skin diseases depend, and then, selecting from these processes those which are most essential and fundamental, to group the affections accordingly. The result has been an etiological division, rather as a necessary consequence of the method than from any original design on the author's part. The most essential pathological processes prove also to be those which stand in a proximate causative relation to the cutaneous affections. The method adopted by Hebra differed from this in that the skin affections were classified according to certain previously observed rules of general pathology. Auspitz's method reaches much further, and seeks to carry the inquiry to what may be termed the prime motives of diseases (Bronson).

By Auspitz's classification the objects classified are not so much the skin affections themselves as the general morbid conditions which tend to the production of skin disease.

Objection has been made to this classification on the score of its want of adaptability to dermatological study. But although not so simple as former systems, its mastery will give a command of the general subject which can be gained in no other way.

Within the last year or two Bronson has, in two able papers, criticised Auspitz's system, and has proposed some modifications which have yet to be acted upon by dermatologists. Reference is made below to these papers.

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Arthur Van Harlingen.

SKIN-GRAFTING (*Greffe épidermique*, Fr.; *Hautüberpflanzung*, Germ.). By this term is meant the application of minute pieces of the outer layers of healthy skin to a granulating surface for the purpose of hastening its cicatrization.

The principle of this method is that, if a piece of living epidermis be transferred to a proper soil it will grow there, and serving as a focus of cicatrization, will unite with other similar points, or with the cicatrizing edges of an ulcer, and thus close it more rapidly and with less subsequent contraction than if it be left to heal from the edges alone. Experience has further taught that this also stimulates the cicatrization at the edges to greater activity.

This little operation received its present general adoption as a surgical procedure in 1869, from Reverdin,[1] an interne in La Charité Hospital, in Paris, and was by him reported to the Société de Chirurgie on December 8th of that year. His report excited great interest, and MM. Guyon, Gosselin, A. Guérin, Duplay, and Marc Sée offered him facilities for further trials, and others in France and other countries, notably Poncet,[2] of Lyons, and Pollock,[3] of London, practised the operation. This was soon found so simple and useful that it immediately became recognized and practised throughout the professional world.

The operation is to be performed by first washing the surface of the ulcer with warm antiseptic solution (mercuric bichloride 1 to 3,000, or carbolic acid two and one-half per cent.), and the surface from which the "grafts" are to be taken with one of double that strength. A minute piece of skin from the cleansed surface is then seized with a pair of fine forceps, lifted up, and snipped off with a pair of fine scissors curved on the flat. For this purpose a pair of single-toothed forceps a little stronger than the ordinary iridectomy forceps, and the usual iridectomy scissors, are the most convenient and quickest to work with. M. Reverdin used a needle to lift the epidermis with and shaved the graft off with a thin, sharp scalpel. A combined forceps and scissors, working together by a single motion, has been invented and is figured in most articles on this subject; but I have found it not nearly so satisfactory as the less expensive and always obtainable separate forceps and scissors. The piece removed should be about the size of the head of an ordinary pin; if larger, it may be made smaller by placing it upon the thumb nail, previously disinfected, and cutting it into two or four pieces according to its size. Only the epidermic layer of the skin is to be taken; the cut surface should not bleed, but should show the blood-vessels underneath. The rete Malpighii is the layer sought for application to the granulations. The little piece is immediately placed upon the granulating surface in the position removed, *i.e.*, cut surface downward, pressed gently into it, with just sufficient firmness to allow it to adhere, care being taken not to cause the granulations to bleed.

The grafts are best applied along the edge of the ulcer, from one-fourth to one-half an inch distant from it, and at equal distances from each other. If the ulcer be not too large they may be arranged in a series of parallel rows across it; or, if the outline be very irregular, a bridge may be thrown across a bay from cape to cape. The arrangement is immaterial, but they should not be applied at a distance from already formed skin, though I have exceptionally found them to "take" when in a group by themselves quite remote from the edge.

After the grafts have been inserted a piece of thin gutta percha protective, previously placed in an antiseptic solution for twenty minutes, is laid over the grafts, extending beyond them over the ulcer if it is large, and beyond the edges upon the skin. This is covered again by a layer of absorbent or borated cotton, and the whole is secured in place by a roller of sublimated gauze bandage. The part should be kept as motionless as possible, so as not to disturb the surface, and the dressing should not be removed for about three days, when the coverings down to the protective should be taken off to see if there be any considerable amount of pus secreted. If the edges of the cotton beyond the protective are soaked with pus, or if pus has dried upon the dressing to any considerable degree, it is all to be carefully washed with an antiseptic solution. A little stream of the solution from an irrigator is best, but the surface must not be wiped with anything, and if it all looks clean underneath the protective, fresh dressings above this are to be reapplied and allowed to remain for three days more. If, however, there be considerable pus, either under the protective or on the cotton, the former must be very carefully lifted off, and a stream of the antiseptic solution allowed to run over the ulcer to wash the pus away. If the grafts are not washed away with the pus a fresh clean piece of protective is to be applied, and the other dressings added as before. This process is to be repeated at intervals of about three days or oftener, depending on the amount of pus found on the dressings, until the "grafts" are seen to have fairly "taken," as will be shown by the appearance on their edges of an extremely thin, smooth, delicate, pellucid, pink line of cicatrization, which indicates the growth of the epidermis over the granulation (Fig. 3532). The protective may then be omitted, and a simple dressing substituted, vaseline or other bland, unirritating salve applied on a piece of absorbent cotton or other substance, according to choice.

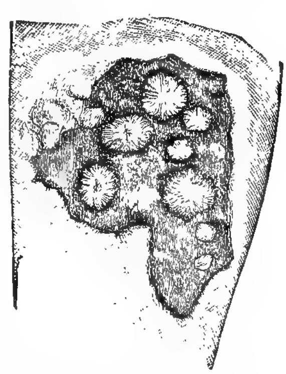

FIG. 3532.—Skin-grafts Growing.

The grafts should be taken from a thin skin, *i.e.*, where the external layers of epidermis are not superabundant or hard—the inside of the thighs, the flexure of the elbow, or the walls of the chest below the axilla—and where there are but few hairs or glands.

The operation itself, therefore, is quite simple; the essential point is the selection of the time when the granulations are in the proper condition to receive the grafts; it is on this more than on any other one point that the success of the treatment depends. They must be suppurating slightly, indicating activity in the blood-supply, but not profusely, or the grafts will be washed away before they have formed adhesions. They should be florid and fresh-looking, soft and succulent, but not flabby nor exuberant, not glazed over nor œdematous and overhanging the edges; nor must the ulcer be excavated or the granulations be hard, bright red, and irritable-looking. They must be in the condition most favorable for cicatrization at the edges, and the surgeon may derive some aid from the circumstance of peripheral cicatrization in determining the proper time to apply the grafts; but he should also be able to judge independently of this by the granulations themselves. The skill of the surgeon consists in bringing the granulations to the proper condition, and in recognizing this when he sees it, rather than in the technique of the trivial operation.

As soon as one set has formed attachments and begun to grow, another set inside of this may be inserted, and again another inside of this, until the ulcer is closed. It depends on the size of the ulcer as to whether it may be entirely covered with the grafts or not; and it is well, if the first set show that the granulations are in a favorable condition to nourish the grafts, to seize the opportunity, and at once cover over a larger surface with them. The advantage of applying the grafts around the edges is that they will form adhesions with the skin of the edges, and thus become connected with the rest of the cutaneous circulation and have a better prospect of living; the supposition being that the island formed by the growth of the graft will not extend indefinitely. The limit of this extension has been placed at an area of about the size of an English sixpence, but I have seen one over the cranium, where the scalp had been torn off, that was much larger than this, and quite unattached at its edges.

After the grafts have been applied for a few days, it will be noticed that they have become quite white and apparently lifeless, and a stream of water running over them will wash off the superficial layers, leading one to think that the graft has separated from its bed, and has not "taken;" careful observation, however, will show that the deeper layers are still attached, the external layers of the epidermis only having separated; while a spot, larger or smaller, pinkish in color and smooth on its surface, remains attached. It is from this that the remainder of the epithelial covering grows.

Scrapings of the epidermis and shavings of corns are said to have been successfully[4] used for grafts, but this plan has not found general approval, as it is too uncertain. Grafts of this kind would naturally have less vitality, be less capable of proliferation, and have less reproductive power than the younger cells of the rete Malpighii.

Do the grafts grow by a reproduction of their own elements? Do the epithelial cells multiply by a duplication of their nuclei? Or do the grafts, *i.e.*, the epithelial cells, act simply as stimulants to the granulations, *i.e.*, connective-tissue cells underneath, causing them to take on an epithelial growth? These questions have been actively discussed by various investigators and pathologists. It was thought that the question was settled when the experiment was made of engrafting the epidermis of a negro upon an ulcer on a white person,[5] the result being that a series of pigmented islands were formed, which gradually coalesced with the surrounding skin, leaving a black cicatrix. The observations, however, have not been uniform, for in other cases the grafts have not been pigmented, and the results were therefore negative. The counter-experiment of white grafts upon a negro is not so valuable, as it is well known that an ordinary, non-grafted cicatrix of an ulcer on a negro is sometimes white, or perceptibly less pigmented. If we may argue by analogy from the development and growth of the tissues from the germinative-layers of the embryo, we certainly are not justified, in the absence of positive observation of the steps of the transformation, in regarding a transformation of connective tissue as ever taking place here.

The newly-formed, like other cicatricial skin, remains thinner than the surrounding integument for some time, and is more liable to break down if subjected to any considerable irritation, or if the patient be attacked by an exhausting disease; but it gradually becomes thicker by the consolidation of the deeper with the superficial layers of the granulations, forming respectively the epidermis or cuticular layer, and the corium or connective-tissue layer. It serves the purpose of normal skin in protecting the parts below, and, except for the absence of all the glandular elements, hair-bulbs, sweat-glands, and sebaceous follicles, it is true skin.

It does not seem to be necessary that the subject from whom the grafts are taken should be living at the time they are removed. Dr. J. H. Girdner,[6] in 1877, used grafts removed six hours after death, taking a large piece from the inside of the thigh of a young man dead from hæmorrhage. This large piece was cut into minute grafts and inserted upon a large ulcer on the arm and back of a boy, ten years of age, who had been burned by lightning some months previously, and the grafts took well. The limit of vitality of the piece of skin after it has been removed is of great practical interest, and has been the subject of much experimentation. Dr. E. P. Brewer,[7] of Norwich, Conn., found that thirty-six hours was the limit of vitality, out of eight trials in which he removed pieces of skin from amputated limbs, and, without any especial care in their preservation, afterward cut grafts from these pieces and applied them in the usual way.

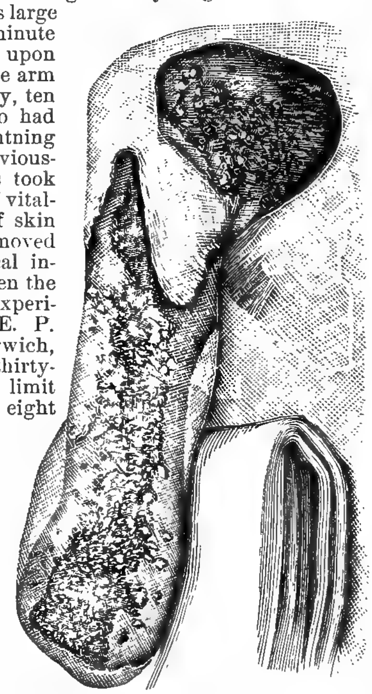

FIG. 3533.—Dr. Girdner's Case of Grafts Taken from Dead Subject.

Georges Martin[8] experimented with grafts kept at different temperatures, and found they preserved their vitality in inverse ratio to the degree of heat, though the longest period that he was able to keep a graft and have it live and take was ninety-six hours, the graft being kept at a temperature just above 0° Centigrade (32° F.). There was a slight difference in favor of "confined" as distinguished from "free" air in M. Martin's experiments.

Grafts have been taken from the skin of animals (zoö-grafting), and have taken root on ulcers on the human subject. The preparation and selection of the skin is similar to that in the case of the human subject. The part is to be shaved, washed, and the grafts taken from the deeper layers. It goes without saying, from what we know of the growth of the skin as already described, that there can be no expectation of a reproduction of hair or other adnexa. Liétevant[9] proposes a nomenclature for the different varieties as follows: Auto-epidermic, when taken from the same person, hetero-epidermic, when from another person, and zoö-epidermic, when the skin of an animal is used.

Of course, great care must be taken, in transferring grafts from one person to another (hetero-epidermic), that the one from whom the grafts are taken be free from any constitutional disease. The danger that syphilis might

thus be communicated, led some surgeons, in the early days of the procedure, to regard the hetero-epidermic method as unjustifiable; but the experience of thousands of operations has shown that by careful investigation such an unfortunate complication may be avoided. On the other hand, Deubel reports a case in the *Gazette médicale de Paris*, No. 35, 1881, in which syphilis was communicated to a father by grafts taken from his son, who was, unknown to the surgeon, the subject of this disease.

In the year following the publication of the account of M. Reverdin's operation, Dr. Frank H. Hamilton[10] claimed precedence for the principle of skin-grafting by referring to an operation which he had performed in 1854, having previously, in 1847, suggested a similar operation to another patient, which was declined. The account of the operation was published in that year (1854). If anyone will, however, take the trouble to read the original description of Dr. Hamilton's operation, it cannot be otherwise than evident that it was simply a plastic operation, a transplantation of the whole skin, after a new method, it is true, but certainly not the grafting of a minute particle of epidermis upon a granulating surface. He[11] calls his operation elkoplasty, or ulcers treated by anaplasty. It was performed for the cure of a large ulcer of the right leg. It consisted in preparing a flap of integument, seven by four inches, from the opposite (left) leg, "extending in depth through the cutaneous and cellulo-adipose textures, until the fascia was in sight," and dissecting it from below, but leaving it attached "by a broad and thick base." This flap he prevented from uniting with the surface from which it was "lifted," by a dressing inserted between them, and *two weeks afterward*, after granulations had formed upon the cut surface, he prepared the ulcer on the right leg for the reception of the flap "by dissecting out the granulations and part of the cicatrix . . . forming a deep bed" into which he inserted the flap after "removing the granulations" from its under surface. The legs were then fastened together, and two weeks after this, or four weeks after the commencement of the operation, "the base of the flap was separated from the left leg, the flap having united through most of its edges and under surface."

This is the application of the principles of the Italian, or Taliacotian, operation to an ulcer which had been converted as far as possible into a fresh wound, not a grafting upon a granulating surface. It is true that Dr. Hamilton found, in the progress of the healing, that the margins of the flap grew into, or extended over, the remaining intact granulations, promoting the cicatrization of the rest of the ulcer; and so far his fourth proposition is the recognition of a before unexpressed principle in the growth of the skin; but practically, he simply made another and fresher margin to the ulcer, and quite failed to appreciate the extent to which the principle of Reverdin's epidermic grafts could be applied. Assuming, for illustration, the absurdity that a surgical procedure may be patentable, it is quite doubtful, if Reverdin had patented his method, whether Hamilton would have been able to claim an infringement; or, if, on the other hand, Hamilton had patented his process, whether any court would have granted him an injunction against Reverdin for infringement.

Presenting a much closer resemblance to Dr. Hamilton's operation than Reverdin's, is the method devised in 1880 by Dr. E. Fischer,[12] of Strasburg, of grafting large strips of skin upon ulcers, both ulcer and skin-flap having been rendered bloodless by the application of an Esmarch elastic bandage previous to the operation. Dr. Fischer first tried rendering the grafts ischæmic, and found that not only was this plan followed by unusual success, but that he could also transfer much larger grafts than had heretofore been possible. Prompted by this, he conceived the idea of rendering the ulcer itself bloodless before making the transference, and he reports the success as even greater; for he found that ulcers of the leg treated in this way might be completely covered with pieces of skin of almost any size, and that they immediately healed without any "secretion," the dissolution and decomposition of the external layers of the epidermis of the grafts did not take place, the wound (ulcer) remained dry. The method was, after considerable experimentation, finally practised as follows: Premising that there be a healthy, recently amputated limb from which to take the strips of skin, the limb to be treated is rendered bloodless by Esmarch's method, care being taken in the application not to wound the granulations of the ulcer, which should be protected by a piece of cloth (Dr. Fischer says silk). The limb from which the strips are taken is to be first carefully scrubbed with soap and warm water, the hair being shaved off, and it is also to be rendered bloodless by the application of a rubber bandage. It is then washed in an antiseptic solution (1 to 1,000 of mercuric bichloride), after which the skin is cut off in strips of from two and a half to three centimetres in breadth, and as long as the ulcer requires. The strips are taken off very close, *i.e.*, free from subcutaneous tissue, the under surface being as smooth and flat as possible. As the strips are applied the surface of the ulcer should be cleaned off with an antiseptic solution from an irrigator, but not wiped, lest the granulations be caused to bleed. The application need not be so extremely accurate, as it is expected that after uniting with the granulations the skin will grow from the edges into and over the remaining granulations, in the same manner as occurs in the case of the smaller grafts, and in this way fill up or cover over the remaining granulation surface. This is in accordance with the principle enunciated by Hamilton in his fourth proposition, *i.e.*: "If smaller than the chasm which it is intended to fill, the graft will grow or project from itself new skin to supply the deficiency." A rubber protective is to be applied over the strips, secured in place by adhesive plaster, and then absorbent cotton and a gauze bandage are applied over all.

This, it is evident, is much more nearly like Dr. Hamilton's procedure than it is like Reverdin's, or than Reverdin's is like Hamilton's. The methods of both the French and the German surgeon differ from Hamilton's in that the grafts are applied to a granulating surface, and have all their connections severed before being applied to the open surface. They have a very close resemblance to the method of skin-transportation, to be described in the next article.

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W. H. Carmalt.

SKIN, TRANSPORTATION OF. *Dermanaplastie*, Esmarch.[1] This is a method of performing plastic surgery, in which a piece of the whole thickness of the skin is entirely removed from one part and transferred to another distant part to fill up a gap.

The term is used to distinguish it from any other form of plastic surgery or transplantation in which a continuity of the flap with the adjoining integument is preserved by a pedicle, of whatever shape or size it may be. The method is a happy development of Reverdin's skin-grafting, associated with, and made possible only by following out the principles of, antiseptic surgery. Gruening[2] proposes to distinguish this as the British method, in con-

tradistinction to the hitherto well-known Italian and Indian methods; and inasmuch as its birth-place is the same as that of Listerism, to which it owes so much of its success, the suggestion is quite pertinent. The author, Dr. J. R. Wolfe,[3] of Glasgow, acknowledges his indebtedness to Reverdin for the idea of transporting small pieces of cuticle to distant parts, but he is entitled to the credit of originality in transporting large pieces to entirely fill up freshly-made wounds, with the intention to get immediate union at all points of contact, but especially underneath. He does not seek to plant a piece in favorable soil and have it increase in size, but to have it grow upon, to simply adhere to, the surrounding and underlying tissue.

The operation is most frequently performed for the correction of deformities caused by the contraction of cicatrices from burns, in which there is no opportunity to perform one of the ordinary plastic operations. The most frequent seat of these operations has been about the face, where the contractions have so drawn upon the skin surrounding one or the other orifices, that the integrity of the contained organ (as the eye) is threatened, or the usefulness of the part itself (as the mouth) becomes impaired, and when the difficulty of getting a piece of healthy skin from the immediate neighborhood, by sliding or transplantation, is great. Dr. Wolfe's first cases were for the relief of ectropion of both eyelids of one eye. There is, of course, no other limit to its applicability in other situations than that all the conditions of success be attainable. These are: 1, Perfect asepsis of both wound and flap; 2, perfect coaptation at all parts, underneath and around the edges; 3, undisturbed rest afterward until union has taken place. How much the size of the flap removed has to do with the success is still the subject of experiment, as is also the question whether there are other points than those above mentioned. In an operation so new as this it is impossible to anticipate all the obstacles that may arise.

The antiseptic precautions to be taken pertain to both wound and flap, to the hands of the surgeon, of his assistants, and of the nurses, to the dressings, the instruments and sponges—in short, to everything used about the operation.

There are now-a-days so many ways of achieving asepsis that it may be superfluous to describe any at great length, and it would be presumptuous to make claim to any one particular method as infallible. My practice is to have both the part to be operated upon and the part from which the flap is to be taken scrubbed first with soap and water, and then, for twenty-four hours before the operation, washed every three or four hours with a solution of mercuric bichloride, 1 to 1000. At the time of operating I usually wash the parts with a saturated solution of iodoform in ether, 1 part to 8, or the solution recommended by De Ruyter,[4] of 1 part of iodoform, 2 parts of ether, and 8 parts of alcohol. The instruments should be laid for half an hour before the operation in a two per cent. solution of carbolic acid; solutions of mercuric bichloride, 1 to 1000 and 1 to 3000, should be at hand for irrigating, and also hot water to add to these solutions as they may be needed in the course of the operation.

Assuming that the operation is for the relief of a cicatricial contraction, an incision is to be made through the skin in the most suitable direction to relieve the deformity, and carried through the subcutaneous connective tissue. It may be necessary to remove a piece of the cicatricial skin, if it be very much thickened and distorted, but it is a good rule to take nothing away that will be likely to live. All contracting bands of the subcutaneous tissue, as well as of the true skin, are to be divided freely, or, if thick and likely to interfere with rapid union, they should be dissected out. In certain places, as in the axilla or neck, care must be taken that this dissection does not involve large vessels or nerves which may have been dragged into the cicatricial bands. This is by no means a theoretical source of danger, for uncontrollable hæmorrhage has occurred from the axillary or jugular veins having been ruptured or cut. Loose pieces of fat or connective tissue are to be removed, and all bleeding points secured; hot water will usually control capillary hæmorrhage, but if a vessel requires ligation it should be tied with aseptic catgut rather than twisted, as a subsequent hæmorrhage is fatal to success.

When the preparation of the wound is thus completed a pattern of cloth is cut of *exactly* the size of the wound; the surface of the latter is then to be carefully irrigated, and covered with a cloth or sponge, wrung out in the warm antiseptic solution, and extending well beyond the circumference. The cloth pattern is then placed upon the skin to be removed to form the flap, and its outline accurately marked out upon the skin, allowing one-third in *every* direction for shrinkage after removal. It is necessary to maintain this proportion in *every* direction; for instance, if the piece is one and one-half by three inches, twice as much must be allowed in the length as in the breadth, and the piece marked out must, therefore, be two by four inches. The incision is to be made perpendicularly through the skin, and the edges all around the flap are to be dissected up from the underlying connective tissue, as little of the latter as possible being removed with the flap. Then, while the main part of the flap is still attached, it is much the best plan to make, according to a verbal suggestion made to me by Dr. E. Gruening, a row of punctures, or small incisions, all around the circumference, for the subsequent introduction of the sutures. For this purpose I have had made a little punch, on the plan of an ordinary shoemaker's punch, which makes incisions about two millimetres in length. These are made perpendicularly to the edge, about eight millimetres apart, all around the circumference, and as they are simply incisions there is no loss of tissue to be repaired, and they gape when the needle is introduced, but close up around the thread as soon as it is drawn taut, leaving no space which requires to be filled up by granulations. The accompanying cut (Fig. 3534) gives a better idea of the instrument than a description. It is made perfectly smooth, with an unlocking hinge, so that it can be taken apart and cleaned, and can be readily kept aseptic. I much prefer the use of the continuous catgut (aseptic) suture, as facilitating a closer union than any other. If the surgeon, however, prefers interrupted sutures, whether silk or catgut, they should now be inserted, with a separate needle for every suture, and after introduction through the flap, *from without inward*, they must be allowed to remain threaded.

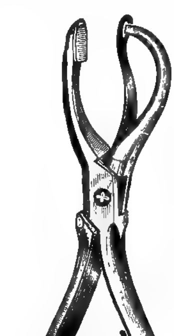

FIG. 3534.

The next step is the entire separation of the flap, which should be done expeditiously and smoothly by means of a very sharp knife, long sweeps being made with it as close to the true corium as possible, leaving no fat or shreds of connective tissue attached. In all manipulations about the flap avoid seizing it with forceps, using the fingers in preference when possible; but if forceps must be used, let them be the single mouse-toothed forceps, which make but one bite or puncture, and not the ordinary dissecting forceps, which crush a considerable amount of tissue included in their grasp. Having removed the flap, place it quickly on the palm of the hand of an assistant, or on a warm cloth dampened with the antiseptic solution, with the epidermis downward and, smoothing it out, with a pair of sharp scissors curved on the flat, trim off all shreds of fat or loose connective tissue which may remain attached to it. This is an extremely important procedure, for the internal surface of the flap should be as smooth and free from every scrap or loose shred of tissue, which may by any possible chance become necrotic and serve as a focus of suppuration, as it is possible to

Skin Transportation.

get it.[5] This trimming is a matter requiring a little patience, owing to the elastic connective tissue of the skin causing it to curl or roll up at the edges. While lying thus with the raw surface upward, the flap should be kept irrigated with the warm antiseptic solution, and as soon as the preparation is completed it is to be turned over upon the wound, previously prepared and free from blood, and fitted accurately to it. The flap must not "pucker" at the edges, neither must it under any circumstances be put upon the stretch by the sutures; it must simply fill up accurately the whole wound. Unless there are angles or other points to determine quickly and accurately the proper adjustment, it is well, as soon as the flap is marked out, to indicate a couple of points upon it, either with ink or indelible pencil, or by means of a thread drawn through it, to correspond with like points on the skin in the vicinity of the wound, in order that no time may be lost, and that the flap be not subjected to unnecessary manipulation in fitting. As soon as it is fitted, it should be pressed down by a soft and warm sponge or cloth, to exclude all air from beneath it, and this pressure must be kept up firmly but gently during the introduction of the sutures, which must now be inserted all around it, without any sliding or other movement of the flap upon its bed. To this end the assistant must keep up the pressure with the soft sponge, uncovering only just enough of the edge to allow the introduction of the needle (curved). The advantage of the incisions previously punched in the flap will now be appreciated, for without them the insertion of the sharpest needles would inevitably drag upon the flap, loosening and disturbing its contact with the parts below, and just so far interfering with the prompt union of the two fresh surfaces. The only reliable alternative is to have as many needles threaded as there are sutures to be introduced, and, as stated above, to insert them beforehand in the flap, so that the subsequent tying of each one may take but little time and make no dragging. The objection to this plan is, that the flap cannot be trimmed at its edges without interfering with the stitches already inserted, and as these should not be more than six millimetres apart, in a flap of any size the number of needles required would be considerable, and threads and needles would almost certainly become so entangled in the necessary manipulations that valuable time would be consumed. I therefore prefer, as stated above, to use a continuous catgut suture, which may be inserted very rapidly, and in which the overlap keeps the edges together better. It is better to insert the needle through the incision in the flap first (from without inward), and carry it then through the sound attached skin from within outward, as this disturbs the flap less; the operator can also see better where to insert the point of the needle than if he approaches the little incision from below. The part is now to receive its final irrigation, and the permanent dressing is to be applied. The particular form of antiseptic dressing employed to prevent suppuration is to be determined by the principles of general surgery. There is of course a wide field for the judgment of the individual operator. In places remote from the eye or mouth, Billroth's "sticky" iodoform gauze (consisting of 10 parts by weight of resin, 6 parts of castor-oil, 16 parts of alcohol, and 5 parts of iodoform, which are used to impregnate 25 parts of gauze) may be placed over the surface, a compress of absorbent or some medicated cotton applied evenly over this, and the whole smoothly yet firmly bandaged over with antiseptic gauze to the exclusion of the air.

The part is now to be left as quiet as possible for five or six days or more—nothing can be done to promote union after the proper dressing is applied. Nature must now be depended upon to do the rest. In obedience to former surgical traditions, I at first applied artificial dry heat to the outside of the dressings, but have lately discontinued it, and with as good results. It is cumbersome in application and adds materially to the subsequent care. The normal temperature of the body will keep the flap warm by contact under the protection of the cotton dressing, so that beyond this I am disposed to regard additional heat as detrimental, in stimulating putrefactive changes.

The method of dressing described, or some other permanent antiseptic procedure, is, according to my experience, greatly superior to any other, but it would be presumptuous, in view of the good results obtained by other surgeons, to say absolutely that it is the best. Wadsworth,[6] Matthewson and Pilcher,[7] and Howe,[8] all used with success some form of transparent covering directly over the wound, viz., court-plaster, gold-beater's skin, or collodion, with pressure from cotton over it. Fryer [9] dispensed with everything but his gold-beater's skin. Dr. Bull [10] had the singular experience in all his cases of having points of suppuration at his sutures only. He used "carbolized silk." All these cases just cited and most of the others were upon the eyelids, and it may be that the greater vascularity of the skin there gives a better chance for the flap to unite; my experience, which has been upon the hands, neck, and scalp, has gradually led me to the adoption of the permanent antiseptic dressing, against which there can certainly be no theoretical objection.

Care must be taken not to apply a dressing that will cause an absorption of the fluids of the flap and its subsequent destruction. While the epidermis is intact the dressing above described, of iodoform gauze and absorbent cotton, answers well, but *when the epidermis peels off early*, as it may do in the course of a week, the dressing had better be modified by the interposition of a piece of india-rubber protective, or other impervious material, between the flap and the absorbent cotton or gauze. If this be not done the flap will become mummified as in dry gangrene, turning black, and becoming as hard as tanned sole leather. I found this in one case, to my great disappointment. The protective may be applied directly against the flap, or, as I think better, between the sticky iodoform gauze and the absorbent cotton, extending well beyond the edges of the gauze.

When the flap of skin is prepared for insertion in the wound, and afterward, it is of course quite bloodless, and the contrast with the surrounding skin is very marked, so much so as often to excite a fear, in one who is not familiar with the appearance, that it may indeed be dead and incapable of being again included in the circulation in its new situation. This appearance continues, indeed, long after adhesion with the parts beneath has taken place, and of course after the re-establishment of the circulation. The outer layers of the epidermis usually become detached in more or less considerable flakes at different periods of from one to four weeks, giving rise again to the fear that the flap is sloughing away; but an attempt to move it from its bed will show that union has taken place.

My experience has been that union takes effect more readily and sooner beneath than at the edges; that the latter do not become firmly united with the main skin, indeed, until after the flap has become quite firmly attached, and whenever a portion only of the flap sloughs it is some part of the edge rather than the centre. Whole flaps may be lost by faulty preparation or after-treatment, but the central portion more frequently unites than the edge, showing that the supply of nourishment is derived from the bed of the wound rather than from the cutaneous circulation. In a flap $4\frac{1}{2} \times 2\frac{3}{4}$ inches, which I inserted into the skin of the neck just below the chin, for cicatricial contraction following a burn, the only loss sustained was at one end, which had been subjected to too much manipulation in the fitting; the central portion preserved its vitality, being nourished of course only from beneath.

The experiences of the pioneers in this branch of surgery, Wolfe, Wadsworth, and others, have proved that a pedicle really plays but a subordinate rôle in the nourishment of a skin flap; that the main source of supply is from the underlying exposed connective tissue. It would seem that this method of *transportation* of large pieces of skin is capable of wider application than it has heretofore received at the hands of surgeons, the modern methods of treatment being much better adapted to obtaining union by first intention.

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W. H. Carmalt.

SKULL, JOINTS OF THE. The skull, as the encloser and protector of the brain, is necessarily a closed shell, affording exit and entrance only to such structures as are absolutely essential. Were it not that in fœtal life it is subject to a very rapid increase in size—which increase does not cease entirely until the age of puberty is reached—it is probable that the necessities of the economy would have long ago obliterated the joints between the bones. We know, in fact, that this must have occurred to a very considerable extent, for as we descend in the animal scale the joints of the skull become more and more numerous, reaching in the osseous fishes a maximum far exceeding the number in man. The same phenomenon occurs in the fœtus. Many of the bones which present a perfect union in the adult are found to be separate in the fœtus and in early childhood, and the sutures which represent this early separation may persist as abnormal conditions. The frontal bone is ossified from two separate halves; the occipital bone from at least five portions; the temporal from four (at an early stage from seven); while the sphenoid may claim to be formed from at least ten distinct ossific integers.

Again, as we advance in age there is a tendency for the sutures to become obliterated. Quite early the occipital and the sphenoid join; indeed, it is so unusual to find an adult skull in which they are separate, that some authors have described them together as a spheno-occipital bone. The parietal bones unite early, and it is not very uncommon to find old skulls in which nearly all the

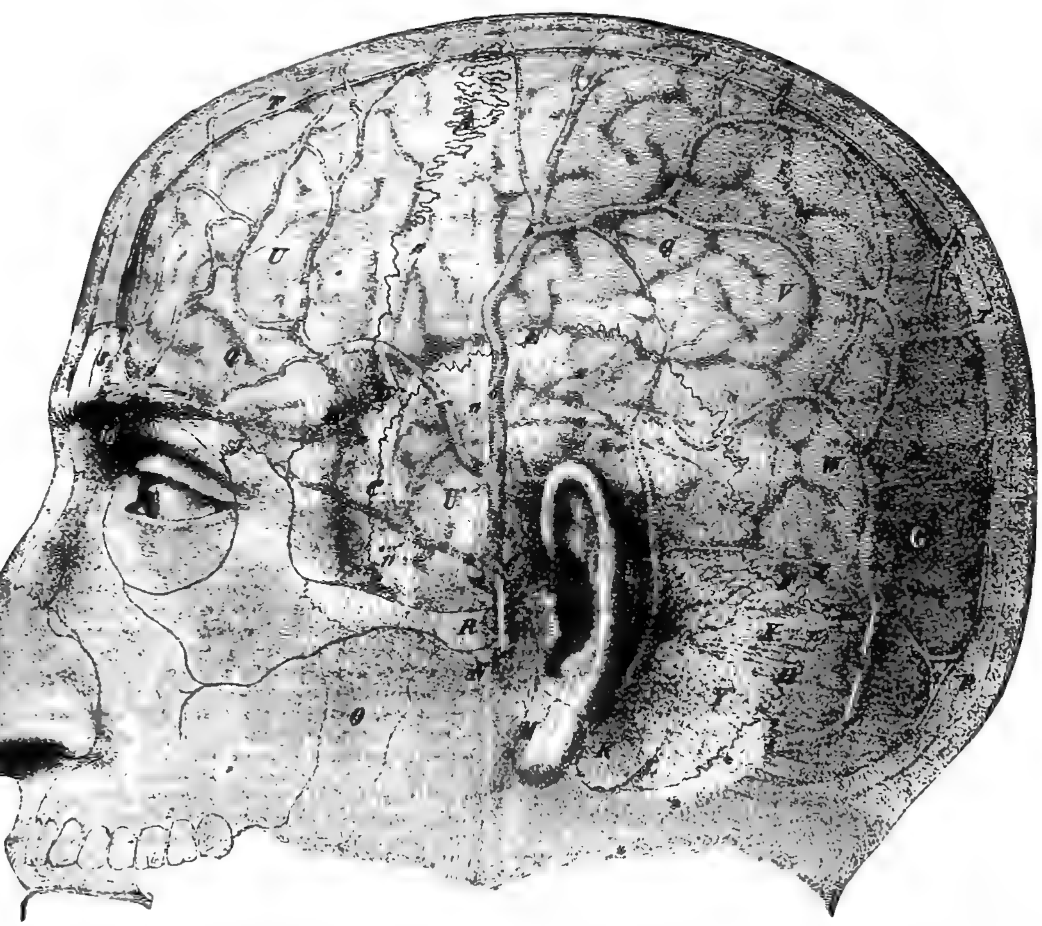

FIG. 3535.—The Anatomical Relations of the Brain to the External Parts of the Head. *A*, Fronto-parietal suture; *B*, fronto-sphenoidal suture; *C*, spheno-temporal suture; *D*, spheno-parietal suture; *E*, temporo-parietal, or squamous, suture; *F*, mastoid suture; *G*, parieto-occipital suture; *H*, temporo-occipital suture; *J*, fronto-zygomatic suture; *K*, mastoid process; *L*, mastoid groove; *M*, styloid process; *N*, spinous process of the sphenoid bone; *O*, pterygoid process; *P*, occipital protuberance; *Q*, *Q*, semicircular line; *R*, zygomatic arch; *S*, frontal sinus; *T*, thickness of the skull; *U*, inferior lobe of the cerebrum; *V*, superior lobe of the cerebrum; *W*, posterior lobe of the cerebrum; *X*, superior lobe of the cerebellum; *Y*, inferior lobe of the cerebellum; *Z*, tentorium cerebelli; 1, superficial temporal artery; 2, middle temporal artery; 3, anterior superior auricular arteries; 4, zygomatico-orbital artery; 5, temporo-frontal artery; 6, temporo-occipital artery; 7, posterior auricular artery; 8, occipital artery; 9, supra-orbital artery; 10, frontal artery; 11, middle meningeal artery; 12, torcular Herophili; *, point for opening the temporo-frontal artery; **, incision for ligature of the superficial temporal artery; ***, upper incision for ligature of the occipital artery; ****, lower incision for ligature of the occipital artery. (From Bruns.)

sutures have disappeared, and the cranium has become, what is doubtless more effective from the protective point of view, a bony case almost without joints.

To this general statement one exception should be made. The mandible or lower jaw articulates by a joint that throughout life remains freely movable. Representing as it does one of the branchial arches, this freedom is assured from the first. The hyoid bone is not, for the purposes of this article, considered as a bone of the skull, although from a morphological point of view it would be quite proper to so class it; for it is developed in one

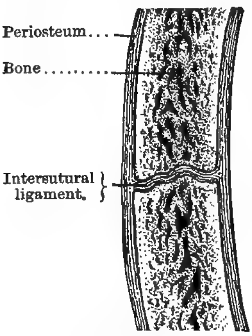

FIG. 3536.—Suture.

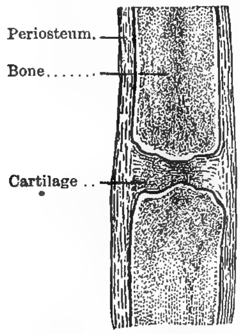

FIG. 3537.—Synchondrosis.

FIGS. 3536 and 3537.—Synarthrodial Joints.

of the branchial bars which appear to be the visceral arches of the same segments which form the cranium.

The joints of the skull are then, with but one exception, immovable. These immovable joints are usually classed together as sutures, but they do not all satisfy exactly the technical definition of that joint, the union between the occipital and the sphenoid at the base of the skull being rather a synchondrosis or union by cartilage (see article Arthrology and Figs. 3536 and 3537).

The sutures form two distinct groups, one antero-posterior, another transverse, in direction. These again are subdivided. In the median line the entire vault is originally separated by the sagittal or inter-parietal suture which connects the two parietal bones, continued downward in early life through the frontal bone as the metopic or frontal suture, and still farther downward as the separation between the nasal and superior maxillary bones in front and the palate behind. The perpendicular plate of the ethnoid, the vomer, and the sphenoid, also show traces of a bilateral separation at an early stage.

Laterally, also, there is a system which runs in a general antero-posterior direction, formed by the frontal bone joining successively the nasal, maxillary, lachrymal, ethmoid, sphenoid, and malar bones in front, forming what is sometimes called the transverse suture; by the parietal joining the great wing of the sphenoid, the squamous and mastoid portions of the temporal. This may be continued back and form a union with the same suture of the opposite side by a suture cutting off the upper part of the occipital bone, thus forming an interparietal bone (see Fig. 3538). This anomaly occurs so frequently in Peruvian skulls that the supernumerary bone is sometimes called the inca bone (os Incæ, of Tschudy and Ribero).

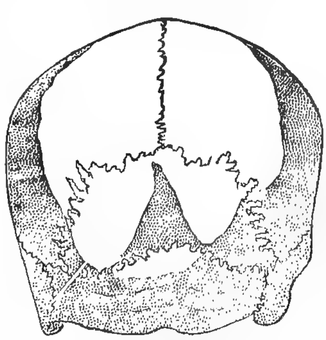

FIG. 3538.—The Interparietal Bone, as Shown in a Peruvian Skull.

The best marked transverse set is constituted by the coronal suture between the frontal and parietal bones, continued downward by the temporo-sphenoidal and occipito-sphenoidal. This usually suffers a slight interruption in man, the wing of the sphenoid pushing back so as to articulate with the antero-inferior angle of the parietal. In the orang the continuity is not interrupted, the temporal articulating regularly with the frontal, and this is the case in about five per cent. of human skulls. (Somewhat more than this in African skulls, judging from an experience of some years in dissecting-rooms, where such subjects abound. See Figs. 3539 and 3540.) The lambdoid suture, between the occipital and the parietal bones continued downward to the base of the skull, as the

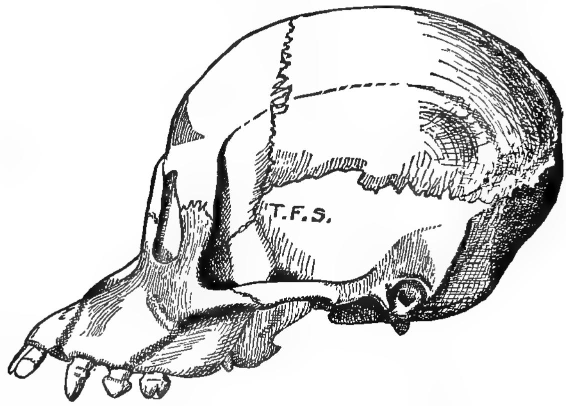

FIG. 3539.—Orang's Skull, Showing Temporo-frontal Suture.

occipito-temporal is also transverse. In the face the indications of transverse sutures (indicating visceral arches?) are more obscure. The palato-maxillary and palato-sphenoid are the principal ones belonging to this class.

The primoidal skull, it should be remembered, is to be considered as a membranous capsule with a cartilaginous base. This capsule is continuous and without joints, and the bones appear as secondary modifications. The increase of size of the capsule is not due to any increase of bone, but to the interstitial growth of the membrane in which the bone is formed. This membrane re-

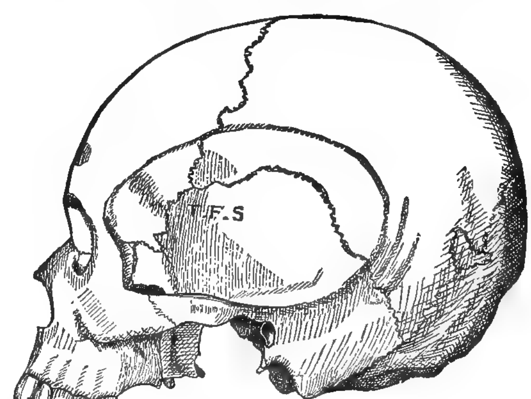

FIG. 3540.—The Same Suture from a Skull in the Author's Possession.

mains, spanning the surface between the bones as long as their growth is insufficient to encase the entire brain.

The growth of the several bones by their edges varies considerably according to their thickness, the thicker bones growing faster. Welcker estimates the growth from birth to adult life as follows:

Frontal bone	along coronal suture		18–22 mm.
Parietal	" "		17–19 "
"	"	sagittal suture	25–33 "
"	"	squamous suture	4 "
"	"	mastoid "	24–27 "

Growth is arrested by the pressure of one edge against another, and, should there be an unusual growth of bone

at any time during childhood or fœtal life, this pressure may be so great as to cause an early obliteration of the suture. This occasions a deformation of the skull which varies according to the sutures affected. In Figs. 3541

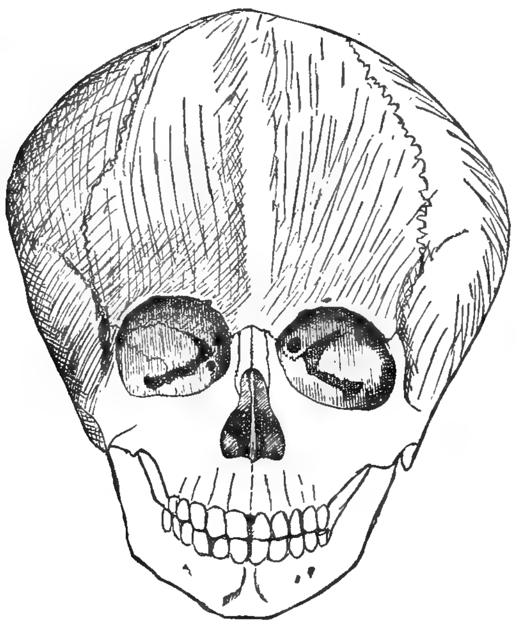

Fig. 3541.—Trigonocephalic Skull. Front View. (After Welcker.)

and 3542 there is a premature union of the medio-frontal or metopic suture. The skull thus deformed is known as trigonocephalic. The suture usually begins to close during the first year after birth and from above downward. It is very common to find traces of it in adult

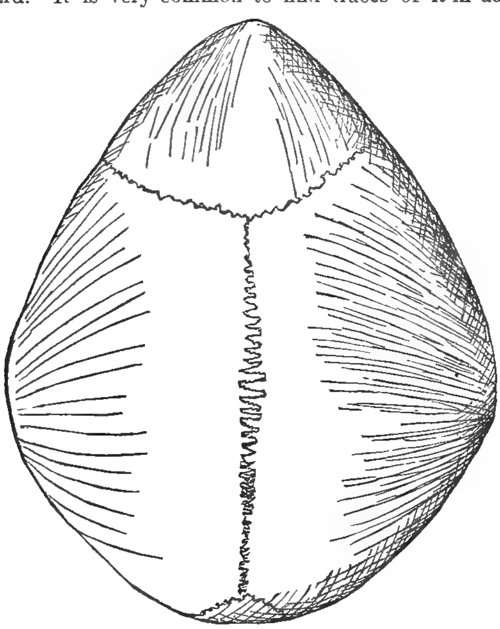

Fig. 3542.—The Same. Top View. (After Welcker.)

skulls. In the trigonocephalic skull it appears to commence to ossify at either end.

By a premature union of the sagittal suture a keel-shaped form of skull is produced, termed scaphocephalic. Examples of this are seen in Figs. 3543 and 3544; and these are by no means uncommon.

There are several types of scaphocephaly depending upon the portion of the parietal bones which first become united. It would appear that, wherever the union may be, it tends to form a constricting band which pushes the brain out forward and laterally. In this way are doubtless produced many of the deformities and asym-

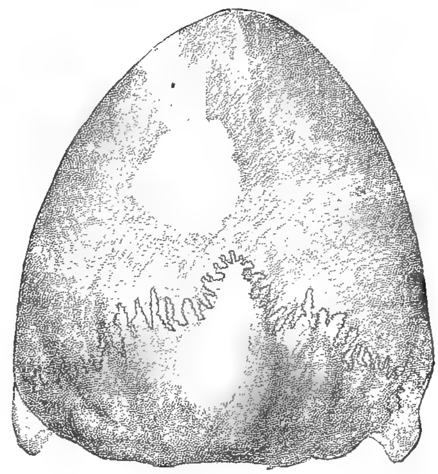

Fig. 3543.—Scaphocephalic Skull, from Behind. (Welcker.)

metries, which are known to be much more common than is generally supposed. An inspection of the outlines which are usually kept by hatters for the blocking of hats, affords convincing proof that irregularities in the contour of the head are frequent. One of the most common is the so-called annular type, shown in Fig. 3545.

This consists of a circular depression situated just be-

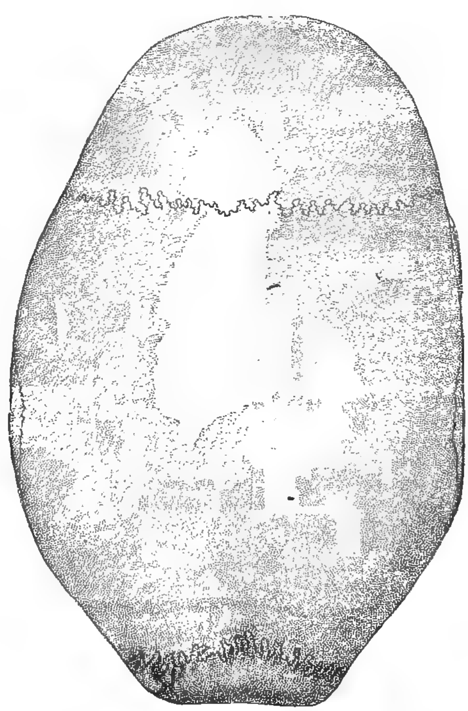

Fig. 3544.—Scaphocephalic Skull, from Above. (Welcker.)

hind the coronal suture, and indicating that the sagittal suture first united at that point instead of further back, near the parietal foramina, as in normal cases.

Another type of deformity is found by the premature

union of the coronal suture together with obliteration of the sagittal. The skull is then turned acrocephalic (see Fig. 3546), as it appears high and pointed. It is well known that the skull of Sir Walter Scott was of this class, as

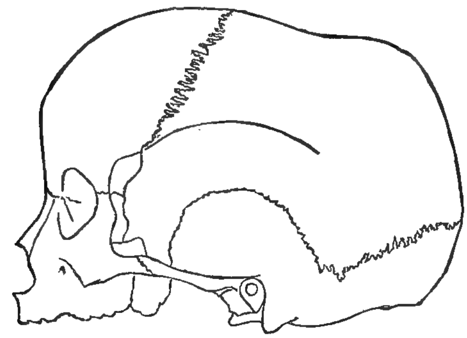

FIG. 3545.—Annular Scaphocephalic Skull. (Topinard.)

may be seen by looking at his portraits. This leads to an interesting series of considerations as to whether these premature unions affect in any way the intellectual faculties. It is clear that in many cases there is no positive

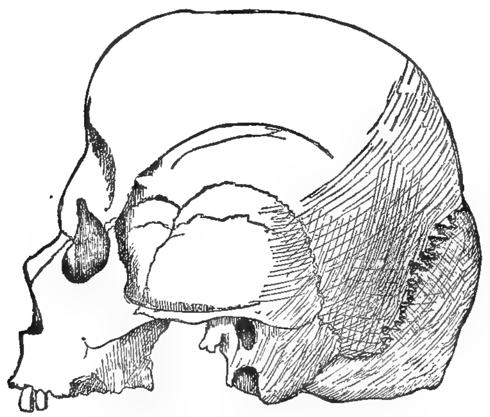

FIG. 3546.—Acrocephalic Skull. (Topinard.)

defect observable, but yet it must be confessed that the evidence on this point, gathered by taking cases of exceptional men, is not conclusive. Statistics gathered from insane asylums show that there are a greater proportion of such deformities found there than in the population in general, and Lombroso holds that there is a much larger proportion also among the criminal classes.

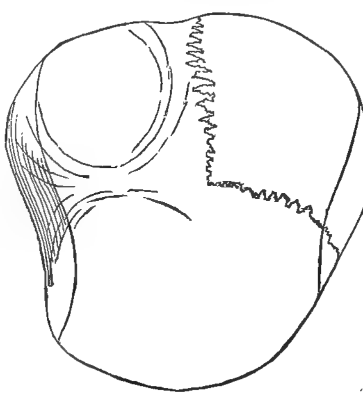

FIG. 3547.—Plagiocephalic Skull. (Topinard.)

In case the obliteration affects only a portion of the sutures involved, there is sometimes produced a twisted appearance in the skull. Fig. 3547 shows an instance of this, which is known as the reniform or plagiocephalic skull.

It has been alleged that the deformities here described are more frequent in the inferior races. Topinard doubts if this is the case, and considering the fact that they are probably not to be considered as phylogenetic characters, but variations depending upon ante-natal conditions or accidental impressions, it seems unlikely that any ethnologic value can be attached to them.

As an opposite condition to early obliteration, undue persistence of fœtal sutures may also occur. This is almost always the case in cases of chronic hydrocephalus. The medio-frontal suture is the most frequently persistent, but the transverse occipital is also found (see Fig. 3538); and occasionally the petro-squamosal portion of the temporal bone and the squamous portion may continue open. Fissures, indicating situations where ossification has been imperfect, may remain and simulate fractures.

A very considerable difference occurs in sutures as regards their character. Some are perfectly simple, like those by which the vomer unites with the two superior maxillary bones; others exceedingly irregular, fitting into each other by jagged margins, sometimes saw-like, tooth-like, wavy, intricately involved with sinuous outlines, like the edges of leaves. This last is especially noticeable in the sagittal and the lambdoid sutures. The coronal suture is usually quite simple above and below, but full of intricate turns at the place where it covers the temporal line. The winding pattern which involves the outer table of the skull is not repeated by the inner table. This has a pattern of its own, and even the diploë between the two has its own peculiar form of joining, which is different from both inner and outer tables. This

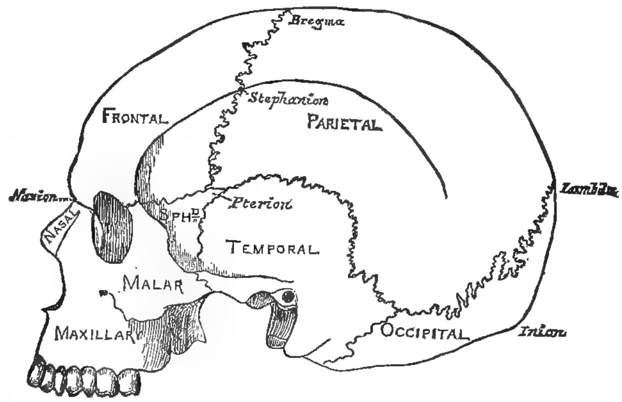

FIG. 3548.—Diagram showing the Principal Craniometric Points on the Lateral Surface of the Skull.

variety in the junction of the different parts lends great stability to the union of the bones, and it is rare that any of the common expedients for separating the sutures, like filling a skull with dried beans and then allowing them to swell in tepid water, does not break the bones apart instead of separating the sutures.

The sutures are extensively used as landmarks from which craniometrical measures are taken. Broca, who may almost be said to be the father of modern craniology, invented a series of terms for the most useful points, and these are now generally used in works which treat of the measurements of the skull. A number of these points are shown in Fig. 3548. They are also useful as topographical data for determining the situation of the convolutions and sulci of the brain in relation to the skull. These relations are somewhat imperfectly shown in Fig. 3535. The upper end of the fissure of Rolando, of the brain, lies nearly two inches behind the bregma (Fig. 3548), or about one inch more than half-way back from the nasion to the inion. The lower end of the fissure of Sylvius is at the pterion, a little over an inch directly behind the external angular process of the frontal bone. The precentral sulcus lies just behind the coronal suture, and parallel to it. The inferior frontal runs forward from it, about on a level with the stephanion. The parieto-occipital fissure is just in front of the lambda.

Fig. 3535 also shows the relation of the superficial arteries, viz., the temporal at 1, with its branches, transverse facial (4), antero-temporal (5), and middle tem-

poral (6), the posterior auricular (7), and the occipital (8). The usual points of ligation are shown by stars.

Frank Baker.

SKULL, PERFORATING TUMORS OF THE. This term is applied to tumors which originate in the cranial bones, and which, during their growth, destroy the entire thickness of the bony wall; it is also applied to extra- and intra-cranial tumors which cause perforation by pressure, atrophy, or invasion of the bone by the neoplasm. With but very few exceptions this group is composed of sarcomatous tumors of the coverings of the skull, the cranial bones, or the dura mater, which, from a pathological and clinical aspect, present certain peculiarities that entitle them to separate consideration.

1. Perforating Sarcoma of the Skull, of Extra-Cranial Origin.—An extra-cranial sarcoma has its starting-point in the skin, in the galea, or in the periosteum. When it develops in the skin primarily, it is frequently found engrafted upon a pigmented mole, or a wart. Tumors of this kind, as a rule, belong to the variety of spindle-celled sarcoma which manifests a marked tendency to infiltration of the subjacent tissues. They penetrate the galea, the periosteum, and the cranial vault. After reaching the dense, fibrous structure of the dura mater, their central extension usually becomes limited, but their growth extends over the surface of the dura mater, between this membrane and the cranial vault. I have seen two patients, both men of middle age, suffering from perforating tumor of the skull of such origin, and which pursued this course. In one of the cases the tumor started as a nodule in the scalp, painless and movable, which had begun, without any apparent cause, twelve years before the patient came under my observation. In the meantime seven operations had been performed. Every successive operation became more difficult, requiring the removal of more tissue. In the last two operations small portions of the skull were removed, and in the last it was ascertained that the entire thickness of the skull had been destroyed by the tumor. When the patient came under my care a pulsating tumor, covered by a dense cicatrix, somewhat oval in shape, and about two inches in diameter, was found to occupy the vault of the skull near the median line, about an inch posterior to the junction of the parietal bones with the frontal. Firm pressure diminished the size of the tumor, but as soon as compression was removed the swelling resumed its former dimensions. The size of the tumor also increased on coughing, or when the head was placed in the dependent position. After each of the previous operations the wound had healed kindly, but within a few months the disease recurred, invariably in the cicatrix. Pulsation could be distinctly felt by the palpating finger over the entire surface of the tumor. On auscultation a slight bruit could be heard, synchronous with the heart's action. The margins of the tumor overlapped the bony defect to such an extent that the opening in the cranium could not be felt. The operation was performed under strict antiseptic precautions. Ether was administered as an anæsthetic. The tumor was circumscribed by a circular incision about an inch from its margins, which divided all the tissues down to the bone. On reflecting the soft parts toward the tumor, a circular opening in the bone was found, about an inch in diameter, with irregular, ragged margins, bevelled at the expense of the external table, and filled by a projection of the neoplasm. The chisel was now resorted to for the purpose of enlarging the perforation, in order to ascertain the condition of the dura mater underneath. On reaching this membrane it was found that the tumor had infiltrated its outer surface and had extended underneath the bone, so that the whole tumor presented the appearance of a cuff-button, the constricted portion corresponding to the part occupying the perforation in the bone (Fig. 3549).* The chiselling was continued until apparently healthy dura mater was reached. The shaving off of the tumor from the dura mater was attended by alarming hæmorrhage, which was followed by a speedy collapse of the patient. I have since thought that the collapse, which was sudden and profound, and which nearly proved fatal, might have been due, in part at least, to the introduction of air into some of the large venous channels which had been opened. The upper portion of the body was lowered to favor blood-supply to the brain, and the hæmorrhage was finally controlled by ligation, compression, and the free use of the actual cautery. This operation was performed about ten years ago, before the time of heroic brain surgery, hence no part of the dura mater was removed. It was hoped that the portions of the tumor contained in the dura mater had been thoroughly destroyed by the vigorous use of the cautery. The patient rallied from the operation, and, a few weeks later, the wound being nearly closed, he left the hospital. I learned subsequently that the disease again recurred in the cicatrix two months after closure of the wound, and that the patient died a year later, having manifested for several weeks prior to death well-marked cerebral symptoms. In the other case the disease started in the scalp, at the junction of the left temporal with the frontal bone. It pursued the same relentless course, proving fatal five years after its commencement. During this time four or five operations were performed by several of the best surgeons in the country.

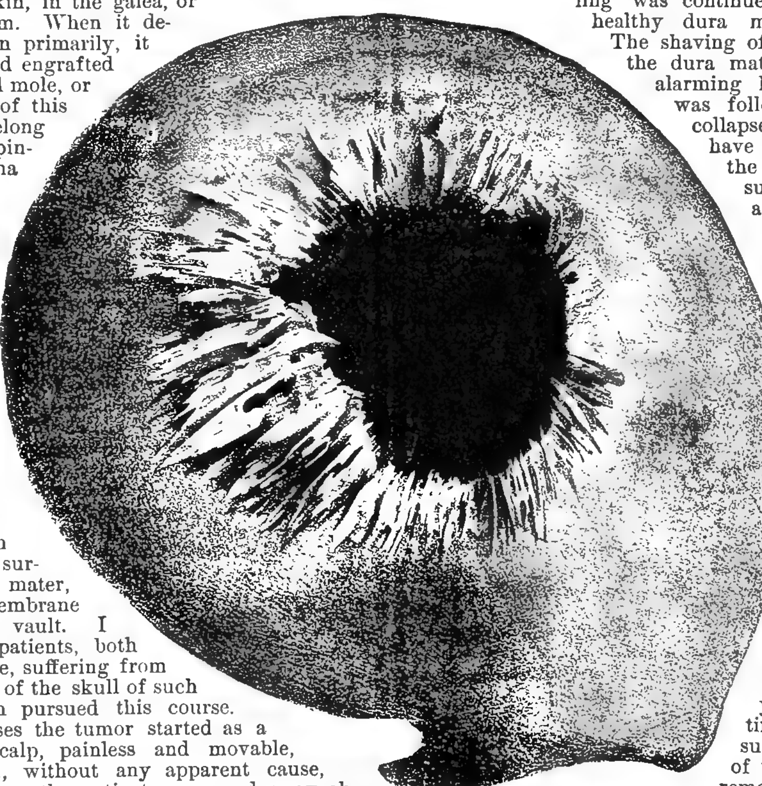

Fig. 3549.—Perforation in the Bone, showing the Osseous Framework of the Base of the Tumor.

One of the most prominent features of an extra-cranial sarcoma is its liability to return, even after what appears a most thorough operation. The recurrence is always local, in the cicatrix. Every successive operation be-

* This and the following illustrations in the present article are taken from Von Bruns' Chirurgischer Atlas.

comes more difficult and serious as the disease penetrates deeper and deeper, following the blood-vessels into the bone, and causing a circular perforation. After it has reached the interior of the skull it spreads diffusely over the outer surface of the dura mater, and at the same time penetrates the meshes of this membrane. When the disease originates in the galea or the periosteum it pursues a more rapid course, as the vessels of the diploë are reached earlier, a circumstance which favors early penetration and perforation.

Pulsation is not a positive diagnostic evidence that perforation has taken place, as a vascular pericranial sarcoma, like any other very vascular sarcoma, may pulsate independently of cerebral pulsation; but in the latter event the pulsations are synchronous with the arterial pulse, and the respiratory pulsations, which are present in a perforating tumor which pulsates, are always absent. A number of such cases are reported by Bruns. A periosteal sarcoma is almost always the seat of formation of new bone, which appears in spurs, traversing the tumor in all directions, imparting to it a degree of firmness proportionate to the amount of bone formed. Figs. 3550 and 3551.

2. Perforating Sarcoma of the Skull of Diploëic Origin.—A sarcoma starting in the diploë of any of the cranial bones is a true osteo-sarcoma, or, more properly speaking, a medullary sarcoma. A medullary sarcoma

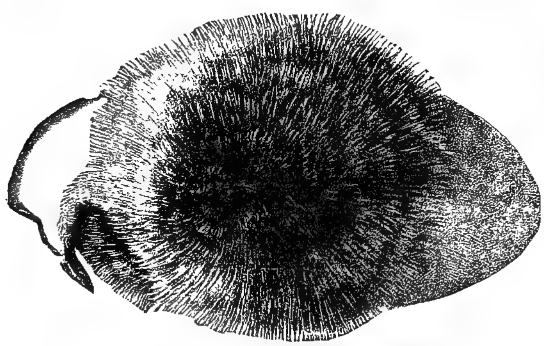

Fig. 3550.—Osteogenic Sarcoma; external surface.

first destroys the structures in its immediate vicinity, the trabeculæ of the diploë, before it affects either of the tables of the bone. When the compact layers are reached the tumor will advance in the direction which offers the least resistance, which is usually toward the external surface of the skull, as the outer table yields more readily to pressure than the inner. The bone expands, and the location of the tumor at this time is indicated externally underneath the scalp by a slight elevation of the smooth external surface of the cranium. The swelling by expansion is of short duration, as the disease infiltrates the compact portion of the bone along the course of the blood-vessels and soon causes a loss of continuity, the defect being covered at this stage by a number of fragments of the external table held together by the neoplasm. At this stage of the disease a crackling sensation is often elicited by the palpating finger. As soon as the tumor has perforated the periosteum extensive and rapid infiltration of the superimposed soft parts takes place. This occasions such a stretching of the overlying skin that ulceration from pressure, atrophy, or some accidental external cause speedily ensues, an event which is followed by protrusion of a fungous, bleeding mass, the fungus hæmatodes of the older authors. While peripheral destruction is going on the disease also travels in a central direction by following the blood-vessels, thus reaching the dura mater and completing the perforation. Only in exceptional cases is the dura mater perforated by the neoplasm. The brain symptoms are usually due to compression caused by the bulging of the tumor toward the cranial cavity, pushing the dura mater before it. In rare cases the disease appears multiple, or becomes so by regional diffusion. Regional infection of the lymphatic glands of the neck has never been observed, but systemic dissemination by metastasis frequently takes place, and death may finally be due to this cause.

Histologically the medullary sarcoma of the cranial bones belongs to the round-celled, giant-celled, or net-celled variety of sarcoma, and very often it appears as a mixed tumor containing two or more kinds of cells. The tumor of the skull described by Kocher as a myxo-sarcoma did not only present pulsation, but on auscultation a distinct and loud bruit could be heard. Heineke, in his article on "Sarcoma der Schädelknochen," describes a case of medullary sarcoma of the skull that came under his observation. The patient was a man, forty-one years of age, who, after having suffered a short time from headache, noticed a small elevation over the occipital region on the right side. This swelling increased quite rapidly in size, so that six months later it had attained quite large dimensions. At this time a swelling formed on the same side over the temporal region, which also increased rapidly in size. The pain in the occipital region ceased at this time, and shifted to the swelling in the temporal region. The general health was not impaired. Seven months later the tumors had attained the size shown in the illustration.

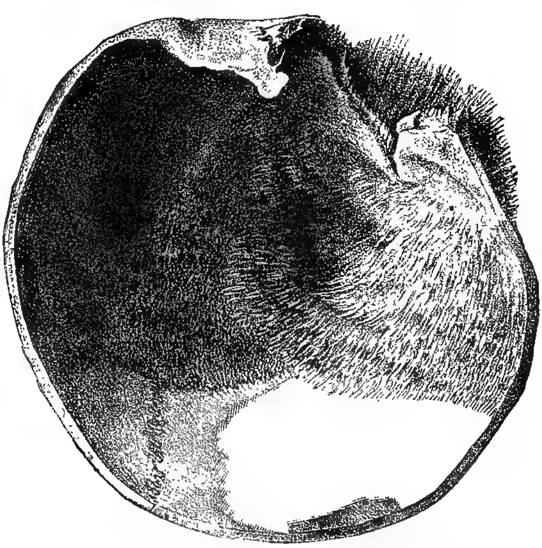

Fig. 3551.—Osteogenic Sarcoma; internal surface.

Both tumors were quite soft to the touch, immovable, but not adherent to the skin. The anterior portion of the ninth rib, on the right side, was also the seat of a tumor the size of an apple. During the operation for the removal of the first tumor it was found that it was surrounded by a distinct capsule. The hæmorrhage occasioned by the incisions necessary for exposing the tumor was alarming. When the margin of the tumor was reached it was found to extend into the bone, and no further attempts were made to remove it. The hæmorrhage was arrested and the wound closed. The patient remained in a comatose condition and died three days later. The post-mortem examination showed that the tumor had its origin in the interior of the occipital bone and contained a framework of bone. The tumor had encroached upon the cranial cavity by pushing the dura mater before it. The internal location of the tumor was marked by a depression of the brain several lines in depth. Microscopically it was composed of an alveolar network of spindle-shaped cells, the spaces of which were filled by large nucleated, round, and polygonal cells. The alveoli contained also numerous blood-vessels, the walls of some of which appeared to be composed of the tumor cells. Where the tumor was attached the dura mater was infiltrated by numerous nodules of the same character as the primary growth. The spurs of bone in the tumor penetrated into, but not through, the dura mater. The tu-

mors in the right temporal bone and the ninth rib were of the same character and structure. Numerous small metastatic deposits were also found in the lung.

But little is known in regard to the etiology of sarcoma of the cranial bones. It is said that it has been observed to follow an injury of the skull, but when we consider how frequently the skull is the seat of traumatic injuries, and how seldom this affection is met with, it is difficult to trace a direct etiological relationship between the alleged cause and effect. Like sarcoma in any other locality, the primary starting-point must be from an embryonal matrix of connective tissue, and a trauma may occasionally, but not always, act as an exciting cause in stimulating the matrix to tissue proliferation by diminishing the physiological resistance of the adjacent tissues. The affection has been most frequently met with in young people, and in those of middle age. The diagnosis is not difficult if the tumor is examined at a time before perforation of the superimposed soft tissues has taken place, as its deep location and its immobility leave no doubt as to its connection with the subjacent bone, while its rapid growth distinguishes it from any benign tumor of the cranial vault. Before the continuity of the surface of the bone has been destroyed by the tumor it might be mistaken for an exostosis, but its growth is more rapid and in a short time the external table of the bone gives way. A periosteal sarcoma in the beginning is softer than a medullary sarcoma, as the latter is covered by the compact layer of the outer table of the bone before perforation outward has taken place. If the tumor has attained a considerable size, it is often impossible to differentiate between a sarcoma of the extra-cranial tissues, of the medulla, or of the dura mater. If, by palpation or by exploratory puncture, it is possible to prove the existence of a framework of bone in the tumor, it is positive evidence that the primary growth started in the periosteum or in the diploë.

The prognosis of a medullary sarcoma is more grave than is that of an extra-cranial sarcoma, as perforation toward the cranial cavity takes place earlier, an occurrence in the history of the tumor which initiates a new source of danger by directly compromising the functions of the brain. While life may be prolonged from five to ten years in cases of extra-cranial sarcomata, death follows a medullary sarcoma of the diploë within a year, or, at best, within two or three years, from extension of the disease to the dura mater, unless the tumor is attacked early and vigorously by operative measures.

3. Perforating Sarcoma of the Skull starting from Dura Mater.—Sarcoma of the dura mater, the *fungus duræ matris* of the older authors, is the most frequent form of perforating tumors of the skull. It occurs as a primary or secondary formation. As a secondary tumor it arises by extension of a sarcoma of the skull, or of the remaining envelopes of the brain, to the dura mater, or by metastasis when a sarcoma exists in any other part of the body. Not infrequently metastatic sarcoma of the dura mater occurs as a multiple formation, and, as the disease, by farther dissemination from the primary tumor, affects at the same time other important organs, a fatal termination takes place before perforation of the skull can occur. Extension of the disease from a primary sarcoma of the arachnoid or pia mater to the dura mater seldom, if ever, leads to perforation of the skull, as the encroachment of the tumor in the direction offering the least resistance produces such extensive and serious lesions within the skull as to result in death before perforation can occur. A primary sarcoma of the dura mater may also extend in a central direction, and produce a fatal result without any perforation taking place. In a number of such cases it has been observed that not only no attenuation of the cranial vault takes place, but the overlying bone becomes thickened by osteophytes which develop upon its inner surface. The cases, however, that present the greatest practical interest to the surgeon are those in which early extension takes place to the skull, resulting in perforation by pressure-atrophy, or by direct infiltration and destruction of the superimposed bone. In such cases the perforation becomes positive proof of the existence of a suspected endo-cranial neoplasm. In the beginning a sarcoma of the dura mater appears as a round nodule, which by pressure upon the adjacent bone causes pressure-atrophy, but perforation is always preceded by a direct extension of the disease to the bone. Analogy and examination of recent specimens tend to prove that infiltration takes place along the course of pre-existing and new blood-vessels. When the neoplasm has reached the diploë, diffusion readily takes place along the numerous venous channels which normally exist in this structure. The defect in the bone presents irregular, oblique margins, the obliquity being caused by the more extensive destruction of the internal than of the external table of the skull (Fig. 3553). As soon as perfo-

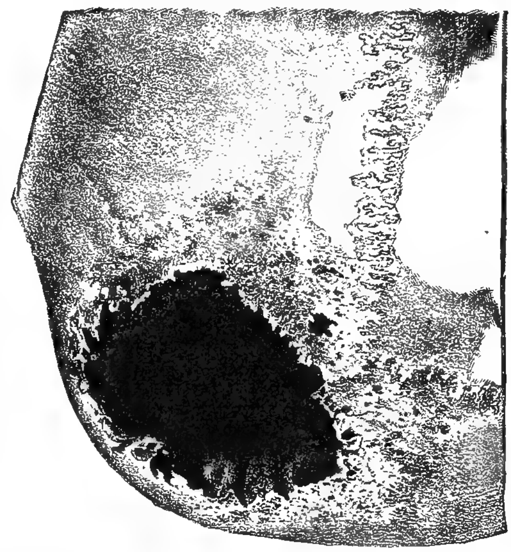

Fig. 3552.—Perforation in the Bone from a Tumor without Osseous Framework.

ration has taken place, the tumor can be felt externally, under the scalp, as a small, elastic, and often fluctuating swelling, which by pressure can be made to disappear completely. At this stage of the disease the defect in the skull can be readily ascertained by making deep pressure with the tip of the index finger, which by indenting the scalp can be insinuated into the opening. Soon after perforation has taken place the tumor extends in a peripheral direction between the cranium and the scalp, thus overlapping the margins of the opening, an occurrence which interferes with further digital palpation of the perforation in the skull. As soon as the tumor has become extra-cranial, it grows with great rapidity and encroaches upon the superimposed soft coverings of the skull, becoming adherent to the tense scalp. Perforation of the scalp usually follows superficial ulceration caused by tension, due to pressure, and by the resulting defective nutrition of the skin. When the skin has given way the tumor appears as a fungous, bleeding mass, which after exposure to the infective influences contained in the surrounding atmosphere, soon breaks down and disintegrates, a rapid loss of substance taking place. The necrobiotic and necrotic changes in the tissues of the tumor, occurring in consequence of infection with pus microbes, is often followed by sepsis which hastens the fatal termination. Until this occurrence has taken place, the patient may have had a healthy appearance, but he now presents a sallow complexion, a rapid, feeble pulse, and a rise of temperature indicative of the existence of a septic condition. The base of the tumor appears attached only to the external superficial layers of the dura mater, or it infiltrates the entire thickness of this membrane. In the former instance, it is easily separated from the dura, in the latter its removal is only possible by excising with the tumor the entire thickness of the dura mater. Sar-

comatous tumors of the dura mater, located at the base of the skull are, as a rule, more liable to encroach upon the contents of the skull, while perforation is a frequent occurrence if they originate in that portion of this membrane which lines the vault of the cranium. Perforating tumors at the base of the skull often appear externally through the frontal sinus, nose, pharynx, or external ear. While sarcomata of the dura mater have often been found in connection with a sarcoma in some distant part of the body as secondary or metastatic formations, it is a well-known fact that a primary sarcoma is seldom the cause of more than a localized dissemination. Volkmann was the first one who claimed that primary malignant tumors of the dura mater were not carcinomatous in their structure and behavior, but that they belonged clinically and histologically to the class of sarcomatous tumors.

A sarcoma of the dura mater always appears as a circumscribed tumor, surrounded by a distinct capsule, while a carcinoma, wherever found, is recognized readily by the absence of any distinct macroscopical boundary-line between the tumor and the adjacent tissues. Microscopical examinations of these tumors have shown that

FIG. 3553.—Perforation of the Skull from within Outward, as seen in Cases of Sarcoma of the Dura Mater.

they are generally composed of spindle-shaped cells, and more rarely contain giant-cells or myxomatous tissue. This affection is found most frequently in young adults, but is not limited to this period of life as it has been met with in young children and persons of advanced age. Among the early symptoms may be mentioned headache, vomiting, and vertigo, manifestations which point to the existence of meningeal irritation. If the tumor is situated at the base of the brain, sight and hearing may be affected. When perforation has taken place, the cerebral pulsations can always be felt over the tumor, a symptom which disappears as soon as its external portion is large enough to overlap the opening in the skull. Arterial pulsation may remain for a longer time, and when present is due to the arterial impulse of the vessels in the tumor. The external tumor may attain the size of a child's head, and always presents a smooth surface and a semisolid consistence. Pseudo-fluctuation is often present, and may lead to a mistake in diagnosis and treatment. If the growth of the tumor encroaches upon the brain as well as the external surface, the signs of cerebral involvement become more prominent, and may include well-marked focal symptoms, such as we observe from pressure due to any other endo-cranial cause. After ulceration has taken place the extreme vascularity of the protruding mass often gives rise to repeated and profuse hæmorrhages, which rapidly undermine the patient's strength, and which also favor local infective processes at the site of ulceration.

The prognosis of a sarcoma of the dura mater is always grave. Without surgical interference the affection leads inevitably to a fatal termination within one or two years. The surgical treatment has so far been unsatisfactory, either because a correct diagnosis was not made early enough, or because the disease had advanced beyond the reach of the surgeon's knife at the time the operation was performed. Before it was deemed safe and expedient to remove a corresponding piece of the dura mater with the tumor the operation necessarily proved a failure, as the neoplasm always invades more or less of this membrane, and hence portions of the tumor were left as starting-points for subsequent return *in loco*. We have also reason to believe that many of the operations proved fruitless on account of imperfect exposure of the endo-cranial

FIG. 3554.—Multiple Perforations from without Inward, in a Case of Periosteal Sarcoma.

portion of the tumor by not removing a sufficiently wide margin of the overlying bone. Before the antiseptic treatment of wounds came into use the removal of an endo-cranial tumor was always an extremely hazardous procedure, as it was necessarily attended by many grave dangers incident to traumatic infection, more particularly septic thrombo-phlebitis and lepto-meningitis. The immediate cause of death in cases that are allowed to run a natural course is either cerebral pressure from extensive growth of the endo-cranial part of the tumor, or, after the extra-cranial portion has broken through the skin, exhaustion from recurring hæmorrhage, or septic infection from the exposure of the tissues of the tumor to the deleterious influences of pathogenic germs brought in contact with the abraded, ulcerated surface.

The medical treatment of sarcoma of the dura mater is merely palliative, and consists in the administration of such remedies as are calculated to meet the most urgent symptoms. In the operative treatment of a sarcoma of

the dura mater, whether perforating or otherwise, it is essential to remove the entire thickness of the dura with the base of the tumor, a step in the operation which is only possible after removal of the bony covering to the same extent by chiselling. In all operations upon the brain or its envelopes the strictest antiseptic precautions must be observed, so as to protect the patients against septic infection. The entire scalp should be shaved, washed with warm water and potash soap, and thoroughly disinfected with a 1 to 1,000 solution of corrosive sublimate. If the tumor has not perforated the entire thickness of the skull, the incisions through the soft parts are to be made in the same manner as for any other endo-cranial operation. If perforation has taken place, a circular incision should be made, at least an inch from the margin of the tumor down to the bone. After arresting the hæmorrhage from the incision through the soft parts, the tissues are separated from the bone, as far as the seat of perforation, by an elevator, and then with chisel and Luer's forceps the bone is removed all around until the endo-cranial portion of the tumor is freely exposed. After arresting the hæmorrhage from the bone, which is apt to be quite profuse, by pressure and plugging of large vessels by a minute aseptic tampon, the surgeon is ready to remove the attachment of the tumor by excising the dura mater, being careful to carry his incisions from half an inch to an inch beyond the visible borders of the tumor. If the tumor is situated in close proximity to the superior longitudinal sinus, or if it lies directly over it, it becomes necessary to resort to prophylactic measures for the purpose of preventing entrance of air, or a serious loss of blood on cutting through this large vessel. Volkmann lost a patient on the table from air-embolism, while he was removing a sarcoma of the dura mater, having severed the superior longitudinal sinus in the dissection. The patient was a woman, sixty-three years of age, who was affected with a perforating sarcoma of the dura mater. The tumor was noticed about two years before the operation, and was located in the region of the posterior extremity of the sagittal suture, and for a long time gave rise to no inconvenience. For the last six months it had caused intense headache. On one occasion a physician, believing that it was an atheroma, attempted its removal, but as the first incision gave rise to copious hæmorrhage he desisted from any further attempts, and the wound healed kindly. When the patient was admitted, under Volkmann's care, into the Klinik at Halle, the tumor presented a lobulated appearance, being composed of three parts, each about the size of a plum, and was located over the posterior extremity of the sagittal suture. To the touch the tumor was soft and elastic, and imparted to the finger a feeling of distinct pulsation. Gradual compression reduced its size one-half, but when the pressure was removed it resumed its former dimensions. On auscultation a blowing sound was heard, synchronous with the radial pulse. By pressing the end of the index finger deeply between the lobes of the tumor a bony defect in the skull was readily detected. The conclusion was reached that the tumor had sprung from the dura mater, and that perforation of the skull had been caused by the prolonged pressure, leading to interstitial absorption of the cranial vault. During the patient's stay in the hospital the tumor increased very rapidly in size. As no brain symptoms were present it was assumed that the substance of the brain was intact. In view of a speedily fatal issue, which of necessity would take place without operative interference, Volkmann decided to remove the tumor. The operation was performed on April 2, 1875. Under strict antiseptic precautions the tumor was exposed by a crucial incision, the flaps with the periosteum being reflected to the margins of the opening in the skull. The aperture in the bone measured five and one-half by four and one-half centimetres in diameter. With a Luer's cutting forceps the opening was enlarged to seven by eight centimetres. The tumor, when exposed, was nearly as large as a fist, and firmly adherent to the dura mater. The dura mater was carefully divided around the margins of the tumor, which had now been liberated from all its attachments, except the falx cerebri. It was now drawn forward through the opening in the skull, and the falx cerebri was divided, the incisions being made from before backward. This step of the operation was attended by alarming hæmorrhage. As the blood was being sponged away to expose the field of operation, a peculiar and characteristic lapping sound was heard, which indicated to all present that air had entered the longitudinal sinus. At the same time the assistant, who was giving the chloroform, remarked, "she is dying." The wound was immediately compressed with a large carbolized sponge. The patient was in collapse, her breathing was interrupted and stertorous. After a short pause it was determined to complete the operation, but as soon as the tumor was again drawn forward and its attachment at the junction of the longitudinal with the transverse sinus was divided, air again entered, accompanied by the same characteristic sound. The tumor was separated rapidly from its remaining attachments, and a Lister dressing was applied in such a manner as to make compression sufficient for the double purpose of arresting

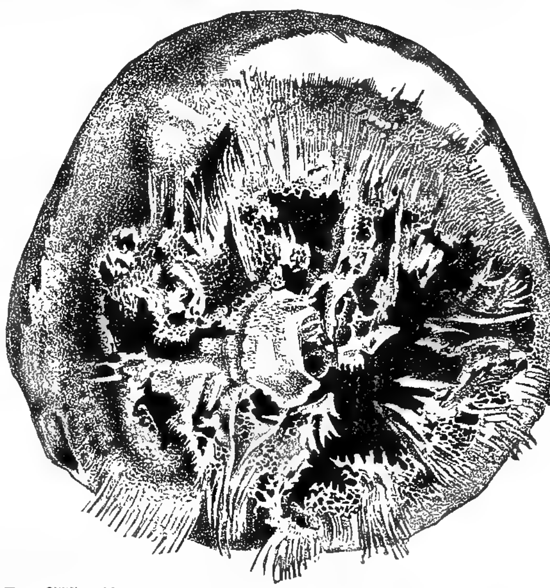

Fig. 3555.—Almost complete Destruction of the Occipital Bone from a Perforating Tumor of the Base of the Skull.

hæmorrhage and preventing further ingress of air. At this time the patient was pulseless, with dilated pupils, and cold and blue extremities. Auto-transfusion, by constricting the arms and legs with elastic bandages, had the effect of momentarily stimulating the heart, but respiration became more irregular and interrupted, and after a few brief moments the patient expired. At the post-mortem examination, which was held on the following day, the right side of the heart was opened under water, and air-bubbles escaped, showing conclusively that air had entered through the longitudinal sinus. The left side of the heart contained no air. Air was also found in the pulmonary artery and in the subpleural vessels. The left side of the brain had suffered more from compression by the tumor than the right. The defect in the dura mater corresponded to the opening in the skull. An additional source of hæmorrhage was detected at the posterior margin of the defect in the cranium, where the opening of a vein in the substance of the bone, five millimetres in diameter, could be seen. Under the microscope the tumor showed small spindle-shaped cells, with a very vascular intercellular substance.

In my experiments on air embolism I determined the fact that entrance of air through a wound in the superior longitudinal sinus can take place only when the head is elevated, as in this position intravenous pressure is diminished, and as, from the unyielding nature of the ves-

sel walls, collapse cannot take place, the essential conditions for the admission of air are thus created. As long as the head is in a dependent position a wound in the longitudinal sinus gives rise to profuse hæmorrhage, but air-embolism cannot occur, as the lumen of the vessel is constantly filled by an uninterrupted column of venous blood. In the same series of experiments I also proved the feasibility and practicability of ligation of the superior longitudinal sinus as a prophylactic measure against air-embolism and hæmorrhage in operations which implicate this vessel, a practice which Kuester had adopted previously in extirpating an endo-cranial sarcoma. It is not only advisable, but positively indicated, to resort to ligation of the superior longitudinal sinus in all cases of ex-

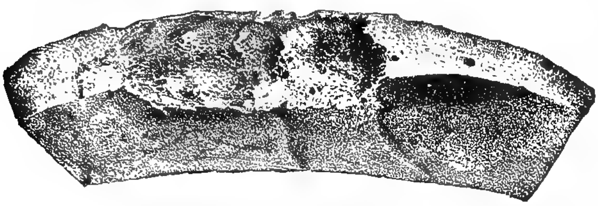

FIG. 3556.—Sarcoma of the Diploë; Tumor encroaching upon both Surfaces of the Skull.

tirpation of sarcomatous tumors of the dura mater whenever it becomes necessary to traverse this vessel by the incision, thus guarding effectually against the two great risks attending such a procedure—air-embolism and profuse hæmorrhage. With a sharply-curved needle two catgut ligatures are passed beneath the sinus, about half an inch apart, and, after tying the ligatures, the vessel is divided between them, and the excision of the dura mater with the tumor is completed. It remains to be shown whether the practice of Macewen, of replanting fragments of bone, after trephining, could not be followed in these cases. This procedure, if it should prove successful, would repair the extensive bony defect that follows the ordinary methods of operating. After arresting all hæmorrhage and closing the external wound as nearly as possible, by suturing, it becomes necessary to apply a thick compress of an antiseptic hygroscopic dressing material, which should always be retained by a few turns of a plaster-of-Paris bandage, so as to prevent all possibility of exposing the wound to secondary infection. If no urgent indications present themselves the primary dressing should be allowed to remain for one or two weeks, after which time there will be but little liability to the occurrence of secondary infection, as the portion of the wound not closed by primary union will be found covered by a layer of granulation tissue, which furnishes the best protection against infection.

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N. Senn.

SLEEP, DISORDERS OF. Sleep is a condition in which consciousness is normally lost, and in which the whole body, but particularly the brain, enjoys functional rest, while constructive and nutritive activity goes on. The most conspicuous phenomenon of sleep is the subsidence of the higher cerebral functions; yet other organs, notably the muscular system, also take part in the resting process. The statement of Foster, that sleep is the diastole of the brain, is therefore only partially true. Persons who lie quietly in bed all night without cerebral sleep get some muscular sleep and a measure of refreshment. For the essence of the state is functional rest and nutritive repair, similar to that which occurs in the cells of the pancreas or salivary glands in the intervals of their activity. We may even rationally assume that in sleep the brain-cells during repose are building up complex molecules, just as the salivary and other glands build up their mother-ferments or zymogen.

The brain, during this period of rest, is slightly anæmic, the deficiency in blood being a part of, but not the cause of, the phenomenon. The remote cause of sleep is inherent in the nervous tissue itself, which follows the great rhythmical law common to all living tissue, of rise and fall in its irritability. It is probable that the immediate cause of drowsiness is the exhaustion of the irritability of the cortical cells and the benumbing of them by the circulation of waste products in the blood. While sleep involves so large a part of the economy, it is true that it is the highest organized tissue, that of the cortex of the brain, which is most affected in this state.

Many facts in the history of the pathology of the brain point to the existence of a sleep centre, which, being especially acted upon, tends to inhibit the consciousness and draw the mind into a somnolent state.

As sleep is only a function, and a passive or a negative one at that, it follows that we cannot speak of its diseases, but only of its disorders, and that these really form but a part of the diseases of the brain, or of general diseases. It is a matter of convenience, however, to discuss some of these separately.

Custom has established the use of certain terms for the various disorders of sleep, and such terms must be for the most part adhered to. It will be proper, however, for the sake of completeness, to arrange the various disturbances we are to discuss in accordance with the modern methods of studying the pathological changes of bodily functions. We propose, therefore, the following classification, which indicates the various depressions, exaltations, and perversions of the function of sleep.

I. State of Normal Sleep. *Hypnosis.*	Somnus.
II. States of Absence of Sleep. *Ahypnosis.*	Insomnia. Egregorsis. Vigilance.
III. States of Imperfect or Partial Sleep. *Hypohypnosis.*	Dreams, sleep-drunkenness or somnolentia, night-terrors, nightmare.
IV. States of Perverted or Artificial Sleep. *Parahypnosis.*	Somnambulism, sleep-walking, hypnotism, mesmerism, trance, somnium.
V. States of Excessive or Frequent Drowsiness and Sleep. *Hyperhypnosis.*	Morbid drowsiness or somnolence, paroxysmal sleep, epileptic sleeping attacks, trance sleep, carus, cataphora, lethargy, sleeping-sickness of Africa.

I. NORMAL SLEEP varies much in accordance with age, sex, the individual, and, to a slight extent, with occupation, race, and climate. The infant sleeps fourteen or sixteen hours out of the twenty-four, the adult needs about eight hours, while the aged live healthfully with but six. Women need half an hour or an hour more than men. A few persons, generally men, need nine, ten, or even twelve hours of sleep daily; others require only six. Brain-workers, as a class, take less sleep than laborers. Sleep is sounder and longer in cold climates and among northern races.

II. AHYPNOSIS.—*Insomnia* is a term given to conditions in which persons simply suffer from insufficient and restless sleep, or from entire absence of sleep for a long time. Such conditions result from a great variety of causes. It is my purpose to discuss only those forms in which the trouble is functional or nutritional, leaving out of consideration the symptomatic insomnia of organic brain disease, and that occurring as the result of painful diseases.

Ahypnosis, entire absence of the capacity to sleep, occurs most often and typically at the onset or in the course of insanity. It is here a prominent and most distressing symptom. The length of time during which a person

can live without any sleep is about the same as that during which he can go without food, viz., three weeks. There are, doubtless, instances in which this period has been exceeded, but authenticated cases are certainly rare. Many hysterical, neurasthenic, or incipiently insane individuals will assert that they have not slept for weeks, but careful examination shows that they have at least been in a drowsy, somnolent condition, which is, in a measure, physiologically equivalent to sleep.

The cases in which persons can only get a troubled rest of a few hours are much more numerous. The young and the old, less often than middle-aged, suffer from this form of insomnia. It is a disorder of the third, fourth, and fifth decades of life. Women are less liable to suffer from it than men, and the laboring classes less than those engaged in business or professional pursuits.

A frequent symptom of neurasthenia is an imperfect, and especially an unresting, sleep. In these neurasthenic cases there is a loss of vaso-motor tone. Ordinarily, as mental activity subsides and sensory excitations are shut out, the inhibitory vaso-motor centre asserts control and slightly exsanguinates the cortex of the brain; but in these insomnic states such action does not occur, the blood continues to flood the tissues concerned in the conscious workings of the mind, and sleep cannot be induced. In gout and in the so-called latent gout, or lithæmia, insomnia is a frequent symptom. One of the few nervous symptoms of secondary syphilis is insomnia. Insomnia may develop as a bad nervous habit, in persons who are neglectful of themselves. It occurs sometimes as a hereditary neurosis. I am personally acquainted with a family in which, for four generations, one or more of the members have suffered from chronic insomnia throughout life.

In anæmia and chlorosis there is often insomnia at night, combined with somnolence during the daytime. Disease of the heart and arteries may lead to insomnia, and under this head come the cases which occur in Bright's disease with tense arteries and anæmic brains.

Disorders of the stomach lead to disturbed sleep oftener than complete insomnia, and the liver, when inactive, causes somnolence rather than the contrary. The poison of malaria, and the toxic agents of fever, must be added to the list of causes of imperfect sleep.

It will be seen from a review of the foregoing that the causes of chronic functional insomnia may be classed under the following heads:

1. Neurasthenic and vaso-motor, including hereditary and habit insomnia.
2. Vascular and cardiac, including heart-disease, arterial fibrosis, and general anæmia.
3. Auto-toxic or diathetic, including lithæmia, gout, and uræmia.
4. Toxic, including syphilis, lead, malaria, tobacco, and various drugs, such as coffee, tea, and coca.

In many cases there exists a combination of these causes.

The forms and degrees of insomnia vary greatly. In children it is accompanied usually with much mental and physical disturbance. The patient is restless, excited, talkative, or querulous and irritable. The insomnic child is more ill than the insomnic adult. In neurasthenic insomnia there is a tumult of thoughts which prevent sleep, or sleep is superficial, unresting, and interrupted by dreams. In many cases of insanity insomnia is characterized by great motor restlessness. In old people insomnia is generally of the quiet kind.

Treatment of Insomnia.—As insomnia in all its phases is often a symptom of some general disorder, treatment of a curative kind must be directed to this. Anæmia, lithæmia, uræmia, malaria, and the other toxic influences must be removed by remedies adapted to these conditions. But besides constitutional treatment there is a symptomatic treatment which will be discussed here.

The older physicians, in treating insomnia, used to depend largely on hyoscyamus, camphor, opium, and the fetid drugs, such as assafœtida, musk, and valerian. Hyoscyamus is still used. It is to be given in large doses, such as five or ten grains of the extract, or even more, and from ten to twenty drops of the fluid extract. The hydrobromate of hyoscine, in doses of gr. $\frac{1}{150}$ to gr. $\frac{1}{100}$ or more, is one of the best forms. Crystalline hyoscyamine does not have so much of the narcotic principle; and amorphous hyoscyamine, which is much like hyoscine, is said to be variable in composition. Hyoscine is indicated in the insomnia of the insane, especially in forms accompanied with motor activity. Chloral hydrate still holds its own as one of the surest of hypnotics. The dangers involved in its use have been somewhat exaggerated, though they are sufficiently real. Doses of gr. x. and gr. xv. are often quite large enough, but in alcoholic insomnia it may be given in twice the above amounts, guarded with carbonate of ammonia. The taste is best disguised by raw whiskey, ice, or a licorice elixir. Not a few persons find that chloral has bad effects. The patient awakes with a dull, heavy sensation in the head, slight headache, or gastric disturbance.

The various bromides are efficient and safe hypnotics if properly used. The immediate effect of them is simply sedative, and sleep is not produced unless very large doses are given. Some persons are even kept awake by average doses (gr. xv.–xx.). In insomnia, therefore, bromides are best prescribed in doses of gr. xv. three times a day. By the second evening sleep is generally secured. The bromide habit is rarely formed, and is in itself not so seriously injurious as the chloral or opium habit. The drug in some cases can be taken in moderate doses for years without doing much harm. Still, in most persons it produces a disagreeable hebetude, anorexia, foul breath, and acne, so that its continual use may prevent the attempts at restorative treatment which are being made. The bromides alone are hardly strong enough hypnotics for alcoholic insomnia, or the insomnia of insanity. I have found them to fail in the insomnia of the aged. While there seems to be advantage to the stomach in varying and combining the bromides, there is no essential difference in their action. The bromide of sodium is the most palatable, the bromide of nickel the least so. Hydrobromic acid causes less acne and hebetude, but it involves the taking large amounts of a strong mineral acid. The bromides are sometimes advantageously combined with ergot (ʒ j. dose) or conium (♏x.–xx. of fluid extract). Paraldehyde ranks close to chloral in its value as a hypnotic. In some persons it disturbs the stomach, but not in all, and it may be used as a hypnotic for months without its power being impaired. It is a disagreeable drug, and there is nothing, so far as I know, that palliates its offensiveness. I prefer, however, to prescribe it in ʒ j. doses, poured upon a teaspoonful of powdered sugar. Doses of ʒ ss. are sufficient to cause sleep in many cases, and collapse may be caused by ʒ ij. given to weak patients. Urethan, in doses of a scruple or more, is a mild and agreeable hypnotic, but not so certain as paraldehyde, and it is at present date very expensive. Amylene hydrate is a hypnotic of similar properties to paraldehyde, but less disagreeable. It is given in doses of about one drachm.

Hypnone, so called, has found no favor as a sleep-producer. Much the same may be said of the various active principles derived from cannabis indica. Lupulin in large doses, gr. x. to gr. xx., is said to be a good hypnotic. Among the antispasmodics are several drugs which occasionally answer well in the insomnia due to nervous irritability. A drachm of the fluid extract of valerian, or of spirits of lavender, for example, may be prescribed. In some forms of insomnia—perhaps best in those due to fever, or pain, or some rheumatic or gouty trouble—antipyrin in twenty-grain doses acts well. It is known that in many cases of mild types of insomnia a dose of whiskey, brandy, or beer will put the patient to sleep. Besides drugs, there are many hygienic or mechanical measures to which the physician may successfully resort—listening to monotonous noises, reading dull or heavy books, counting, or keeping before the fancy some blank or wearying picture—

> "A flock of sheep that leisurely pass by,
> One after one: the sound of rain and bees
> Murmuring; the fall of rivers, winds and seas,
> Smooth fields, white sheets of water, and pure skies."

The mechanical remedies have nearly all for their purpose the withdrawal of the blood from the brain to the skin and abdominal viscera. Hot foot-baths, or warm general baths, cold douches down the spine, beating the limbs with rubber hammers, brisk exercise, a light meal, massage, all are at times efficient hypnotics. Persons who suffer from insomnia should sleep in cold rooms, the head should not be too high nor very low, and in most cases they are better without late suppers, even though these be light. Mental work should be laid aside several hours before retiring, and the evening devoted to quiet conversation and reading, or amusements that do not actively excite the nerves. Many persons live in good health though they sleep in the day and stay awake at night. Journalists and editors, whose work obliges them to go to bed in the early morning, often continue for years without impairment of physical vigor. Yet despite this, it is true that the best time for sleep is at night, and that the old maxim, "early to bed," is a sound one. The human system requires a certain amount of sleep, and should have it. The industrious and ambitious often try to train themselves to shorter hours, but, though they may succeed for a time, nature will not be cheated out of her due, and health suffers in the end. It is a widespread custom in some countries to take a short nap in the daytime, and the custom is a good one. America has not adopted it, but might do so with benefit to the health of her brain-working class. Many from childhood up do not get a sufficient amount of sleep.

III. Disorders of the Hypohypnotic State.—These are: *dreams, sleep-drunkenness* or *somnolentia, night-terrors, nightmare.* Sleep is said to reach its deepest stage in from one to two hours after it begins. There is then after this a gradual lessening of the depth of sleep. Probably there are great variations in this rule, for many persons seem in soundest slumber several hours after falling asleep. But, at any rate, there are lighter stages of sleep at its inception and toward its end. These are the favorite times for dreams, and at this period also there develop the peculiar phenomena of sleep-drunkenness.

Dreams.—When sleep is perfect and profound, dreams afterward remembered do not occur. Dreaming is, therefore, a morbid symptom, although often of trivial significance, especially if it occurs at about the time of natural waking, when slumber is, in its physiological course, passing into the lighter stages. In sleep, no matter how light, the action of the regulating centre which directs thought, controls emotion, and exhibits itself in volition, is suspended; the psychical mechanism, if excited to action at all, works without purpose, like a rudderless ship at sea. Ideas and emotions succeed each other by the laws of association, but are not properly correlated, and judgment and logical reasoning are gone. As a rule, dreams are made up of somewhat ordinary ideas and fancies incoherently associated, and shifting too rapidly to call up much feeling. When from some point in the body painful sensory excitations do excite disagreeable images, emotions of a most violent kind may be felt.

Dreams, when painful, depressing, or unusually vivid in character, are called morbid, and Hammond speaks of symptomatic morbid dreams and essential morbid dreams, or nightmare. But while there are, doubtless, cases of nightmare in which the trouble is a pure neurosis, or vice in nervous structure and nutrition, yet, as a rule, the characteristic symptoms of nightmare are excited by some agent which is recognizable. It is, therefore, also symptomatic.

In the earlier stages of civilization, among primitive people, dreams were comparatively rare. When they did come with vividness they were regarded with importance, and often were considered visitations of spirits. Civilized man dreams more, but he has learned to treat his fancies with corresponding indifference. The attempts of scientific men to formulate laws regarding them have been productive of small results. Some diseases, however, produce, as a rule, dreams of a more or less peculiar kind. Thus heart disease is accompanied with dreams of impending death. Previous to attacks of cerebral hæmorrhage, patients have dreamed of experiencing some frightful calamity, or of being cut in two. Dr. Thos. More Madden states that intermittent fever is often announced by persistent dreams of a terrifying character. Hammond ("Treatise on Insanity") has collected a large number of what he terms prodromic dreams, all going to show that, before recognizable signs of disease are present, morbid dreams of various kinds may occur. Albers, quoted by Feuchtersleben, has given a complete summary of his views regarding the significance of dreams. Among his dicta are these: "Frightful dreams are signs of cerebral congestion. Dreams about fire are, in women, a sign of impending hæmorrhage. Dreams about blood and red objects are signs of inflammatory conditions. Dreams of distorted forms are frequently a sign of abdominal obstructions and diseases of the liver." Lyman asserts with truth that in certain somnolent states the brain becomes extraordinarily sensitive to external impressions, hearing in particular being greatly intensified. He asserts that at one time he always was awakened nights several minutes before his bell rang. When thus awakened he could at first hear nothing, but felt perfectly sure that the bell would ring shortly. Dr. Lyman would explain some of the cases of alleged thought transferrence on this theory of somnolent exaltation; but here we are treading in regions of the undemonstrated.

Nightmare.—That nightmare is a disorder incident to the hypohypnotic state, or that of incomplete sleep, is, I believe, strictly true; for though the cause of nightmare may act upon the patient while sleeping soundly, it must first bring him into the somnolential state before he experiences his sufferings.

Nightmare is one of those minor ills that are nearly always symptomatic of an irritation in some part of the body. The usual causes of it are some digestive disturbance (repletion) and cardiac disease. Persons of a nervous temperament are more subject to it; and there are individuals whom it makes suffer all their lives. The popular belief that sleeping on the back favors it, is, in general, a correct one. When nightmare occurs in cardiac disease a certain position, semi-recumbent or on the right side, must be maintained, or the painful fancies awaken the patient.

Healthy people can get sound sleep whether lying upon the back, the side, or the stomach. But light sleepers, and those with sensitive abdominal viscera, generally find that the position on the right side is the most comfortable, and less provocative of unpleasant dreams. Prolonged mental or physical strain, excitement, and worry predispose to nightmare. Farinaceous foods, excessive use of strong liquors, coffee, and tobacco, all have a similar tendency.

Nightmare occurs also in anæmia and malaria, and it may, in fine, be excited by painful sensations in any part of the body. It sometimes occurs about the menstrual period in women. Its most common feature is a sense of suffocation or impending death.

Pavor nocturnus, or night-terrors, is a sleep disorder peculiar to children. It is allied to nightmare on the one hand, and sleep-drunkenness on the other. It differs from the former condition in that the child continues to suffer from the distressing fancies for some time after he is awake. Night-terrors occur usually one or two hours after sleep has begun. The child wakes up screaming with fright, and perhaps runs about the room or seeks its parents for protection against some imagined harm.

The disorder occurs in weakly, anæmic, nervous, or rheumatic children. It is due sometimes to lithæmia, or, as the older writers put it, rheumatism or gout of the brain. Digestive disturbances, worms, dentition, hereditary syphilis, mental strain, fright, and excitement are placed among the causes. It sometimes appears to be a paroxysmal neurosis allied to epilepsy. The disorder is usually harmless, and the prognosis favorable.

Somnolentia, sleep-drunkenness, *Schlafentrunk*, is a condition of incomplete sleep in which a part of the faculties are abnormally excited, while the others are buried in repose. It is a kind of acted nightmare. The person affected is incoherent, excited, and often violent. He experiences the delusion of some impending

danger, and while under it acts of violence have been committed. The condition is one of medico-legal importance, therefore, and has been discussed by writers on that science (Wharton and Stillé). Minor degrees of it are often noticed in children, and in adults who are roused from a very profound sleep. It at times becomes a habit, and a most annoying or dangerous one. The disorder, in its severe form, is fortunately a very rare one. Some of the classical cases are the following:

A sentry, on being suddenly awakened from sleep by an officer, made a violent attack upon him with a sword, and would have killed him but for the interference of others.

A laborer who had been sound asleep was awakened by his wife. He sprang up and dealt her a fatal blow.

A woman dreamed that her little boy told her the house was on fire. She jumped up and threw him out of the window.

Although sleep-drunkenness is a phenomenon of imperfect sleep, and belongs to the states of hypohypnosis, yet it seems often to occur in those who sleep very profoundly, and is, therefore, somewhat different etiologically from the states of dreaming and nightmare.

The treatment of morbid dreams, nightmare, and pavor nocturnus must be directed to a removal of the causes. Tonics, cardiac stimulants, laxatives, anti-rheumatics, attention to diet, are called for according to the condition of the patient. Change in surroundings is often necessary. Among symptomatic remedies the bromides are the best, except in lithæmia, when alkalies and salicylates may prove more serviceable. In somnolentia the patient should be prevented from getting into too profound a sleep. He may be awakened once or twice during the night, or take a nap in the daytime. The head in sleeping should be raised high, and the body not too heavily covered.

IV. PARAHYPNOSIS. — *Somnambulism, Sleep-walking, Somnium, Hypnotism, Trance, Mesmerism.*

Somnambulism.—Some authors have regarded somnambulism as an incomplete sleep (Symonds, Hartmann, and others). Dr. Chambers thinks it is a condition of unusually profound sleep. It appears to me to be a condition peculiar to itself, and not to be classified under the heads of incomplete or too profound slumber. Hence I adopt the term for it of parahypnosis.

Somnambulism is a condition similar to hypnotism or the mesmeric state. In it volition is abolished, and the mind acts automatically under the dominance of some single idea. Sight, hearing, and nearly all the avenues of sense are closed. The sleep-walker avoids obstacles and performs ordinary acts automatically, like an absent-minded man, which in reality he is. All those mechanisms which have been trained by constant repetition to act automatically, like that which preserves equilibrium, are preserved, and their powers may even be heightened, so that the somnambulist may walk along roofs or on dangerous roads, and thread intricate passages without harm. The automatism of the somnambulist may continue for hours, until a journey has been performed or a task completed. He may carry out with success intricate mathematical calculations, write a letter, or work upon a picture, but he only follows along the lines established by constant iteration in his waking moments. He can originate nothing new. He is roused from his state with difficulty, and when out of it he remembers nothing of what has occurred.

Somnambulism usually arises, according to Chambers, from overeating. Sleeping with the head too low is another cause. Violent emotions, according to the author referred to, act only indirectly by disturbing digestion. The habit being once established, however, attacks occur without apparent cause. The disorder occurs oftenest in young people about the age of puberty, and it then attacks the sexes alike. Later in life women are more often affected. The disease is fostered sometimes at school by the attentions of the school-mates. In most cases a condition of morbid nervous sensitiveness underlies it. The patients are neurotic. Hereditary somnambulism has been observed. Its attacks have alternated with those of catalepsy. They are likely, after a time, to become periodical, occurring every week, fortnight, or month.

The somnambulic state may come upon a person in the daytime. It is then regarded as spontaneous trance, or hypnotism. It is not the case, however, that persons who are easily hypnotized are usually somnambulists, though the reverse may be true.

Somnambulism is a term that should include not only sleep-walking, but sleep-talking, and Chambers even considers that spermatorrhœa and nocturnal enuresis are disorders allied to it. In this, however, it seems to me he is mistaken.

The treatment of somnambulism is very much like that for sleep-drunkenness. The patient's surroundings must be investigated, and unfavorable influences, such as may occur at school or from injudicious nurses, be removed. He should be prevented from sleeping too soundly, the head should be raised, the clothing light, the diet regulated. Remedies like iron, quinine, phosphorus, and cod-liver oil may be given. When the patient is discovered in the somnambulistic state, he should not be awakened, or at least not until he is safely back in bed.

Hypnotism, Trance, Mesmerism.—This is a state in which phenomena allied to those of perturbed sleep are exhibited.

Definition: Hypnotism is a morbid mental state characterized by (1) perversion or suspension of consciousness; (2) abeyance of volition; (3) automatic response to commands or external sense impressions; and (4) intense concentration of the nervous force in some particular direction.

Susceptibility and Causes.—Hypnotic states are generally produced artificially by causing the patient to concentrate the attention on an object, while certain muscles, generally the eye muscles, are kept on a strain.

Young persons, the hysterical, those of sensitive nervous organization, of deficient education, and weak will-power are most subject to the state. About one in every ten or fifteen adults is susceptible to the condition. It can be produced in the lower animals. Those who have been mesmerized once are more easily affected afterward, and may even pass into the state involuntarily. Indeed, by cultivation almost anyone can train himself to enter it at will.

Symptoms.—The person who has been hypnotized at first sits or lies quietly in the position he had assumed during the manipulations of the operator. No notable physiological changes occur, as, for example, in the pulse, respiration, temperature, pupils, skin, etc. Some increase in the cerebral blood-supply, however, is said to be present. The patient will now respond automatically to any outside command, or will be dominated by any idea which is suggested to him. He will talk, or walk, or run, or gesticulate, assume expressions of fright, anger, or joy, entirely in accordance with the command given. Apart from these commands he is entirely dead to the outside world. He hears, sees, smells, tastes, and feels nothing. He can be burned, cut, or injured without showing any signs of feeling. At a suggestion he may be made cataleptic, somnambulic, or paralytic. This state is termed *somnambulistic trance.* If left to himself, he gradually sinks into a deep sleep, from which he can with difficulty be roused. After a time, rarely more than one or two hours, he awakes as from ordinary slumber. This latter state is called trance-coma, or *lethargic hypnotism.* The attempts of some French writers to divide hypnotic phenomena into three forms, the somnambulic, cataleptic, and lethargic, are hardly successful. Sensitive subjects can be thrown at once into lethargy, catalepsy, or somnambulic states, at the command of the operator.

The phenomena of hypnotism depend upon the wonderful sensitiveness and quickness of the subject in responding involuntarily, with all his nervous energy, to outside suggestion. Dishonest persons may learn the latter trick and thus simulate the hypnotic state. Travelling mesmerizers utilize such persons largely, hence no confidence can be placed in the phenomena exhibited by them.

The best method of inducing hypnotism is to hold for

five to ten minutes some bright object at a distance of six to eight inches from the eyes, and a little above the horizontal plane of vision.

Hypnotic states may be self-induced, by rigorously fixing the attention upon some object. The ecstatic states of the saints, and the nirvana of the Buddhists, are forms of hypnotism; so also are the trance states into which some clairvoyants and spiritualistic preachers place themselves; this same curious phenomenon is at the bottom of the so-called "mind-healing" science, and it enters into rational therapeutics and orthodox religion. The capacity of the human mind for hypnotism or semi-hypnotic states is, therefore, a most curious and important fact.

After a time, as already stated, subjects who have been hypnotized learn to pass into the state much more easily; even a word of command being sufficient.

The practice of hypnotizing persons is injurious to them, tending to exhaust the nervous force, and weaken the will. It should be done only with the greatest care. Its utility in therapeutics I greatly doubt. It may relieve symptoms in the hysterical for a time, but it cannot be of permanent benefit, and is likely to lead to actual harm. The popularization of mind-cures, Christian science, etc., accomplishes its results at the expense of mental demoralization, and faith-healing institutes are more pernicious elements in society than gin-mills.

Patients naturally come out of the mesmeric state through the channel of deep sleep or lethargy. Ordinarily they are dehypnotized by word of command, or by a pass of the hand, or any such impression which the patient expects to be used for the purpose.

Hypnotized persons have been observed to have a diminution in the spinal reflexes, and a muscular hyperexcitability. They sometimes show a most extraordinary exaltation of visual, auditory, or other special sense. The statements of Luys and other French observers, that they are sometimes susceptible to the action of medicines at a distance, enclosed in sealed vials, can hardly be credited. The alleged phenomena must be explained at present on the theory of unconscious suggestion.

Something may be properly said here regarding the physiology of the hypnotic state.

Physiology.—1. There exists in each of us what the philosopher Locke well described as a "power to begin or forbear, continue or end the several actions of our minds and motions of our bodies, barely by a thought or preference of the mind." This power is called the Will. It is not thought by modern psychologists, or even by all of the older schools, to be a separate and distinct force enthroned within us. Exactly what it is, however, is a question that we need not enter upon now. We do know that every man can check, regulate, or set in action, such muscular movements, or such trains of thought as he wishes. One can understand that if this power were taken from us, it would materially limit our physical and mental being. We should be very much like machines, acting only, or chiefly, under certain stimuli applied from without. Our actions would then be essentially reflex in character. The reflexes would differ much in complexity, however, and they may be roughly divided into three classes:

(*a*) The first embraces the simple reflex actions, which are processes belonging pre-eminently to the spinal cord and medulla.

(*b*) The second class embraces higher centres and more complex activities. Human beings all possess more or less of certain dexterities, such as riding, walking, the playing on musical instruments, etc. There are a few of these, such as suckling, which are possessed even at the time of birth. But the most are acquired by practice. Whatever their kind, the individual goes through the various complicated movements pertaining to them, for the most part unconsciously. Thus, a person can walk, or dance, or play, and be entirely unconscious of expending any voluntary effort. We characterize these acquired and these inborn dexterities as automatic; and such, indeed, they are, using the term automatic in perhaps a rather loose sense. They are machine-like in character. Once being started they go on as a clock does when it is wound up. And we suppose that the particular place where this machinery is located is in the lower ganglia and hinder part of the brain. The cells and connecting fibres in these ganglia have become arranged into definite groups, each corresponding with and governing certain classes of muscular movements. All that is needed to set or keep these groups at work is the proper stimulus or successive stimuli; they then go on discharging efferent impulses, and producing the definite motor results.

We have an example of this in the inception and continuance of an ordinary walk, or in playing a well-known piece of music. It is a case like that of setting a machine going by the turning of a key. The brain's co-ordinating mechanism is generally set in motion at first by conscious impulses from the higher brain-centres, themselves roused by the visual sense. But after a time it may also be stimulated by afferent impulses that do not rise to consciousness. When the impulses go to and fro without exciting consciousness, we suppose that they do not pass up to the cortex at all, and that only the lower ganglia are active. The reflexes are genuine, but more complicated than those of the spinal cord. We may class them as reflexes of the second order, or of the middle projection system.

(*c*) There is still a third and higher system of reflexes. Thus, a person sees an object which excites in him emotions of fear, or hears a suggestion which excites an idea, and which in turn excites the desire to cry out. In the former case we trace the afferent impulse along the optic nerves to the part of the brain concerned in sensation and ideation, and that process of linking the two which is called perception. From these higher centres efferent impulses start down to the facial or other muscles, and the expression of fear is seen upon the countenance.

In the second case the process is a similar one. The afferent impulses give rise to a sensation which links itself to the previously impressed sensations (now become ideas), and a train of thought is aroused. After travelling through this ill-understood nexus between the afferent and efferent impulses, the latter excite the organs of speech.

In these various processes there is normally almost always a consciousness of the changes that are going on. The changes include sensation, perception, ideation, and what is known as volition.

Again, here, as in the second class of reflexes, the afferent impulse need not be constantly acting. It may start the machinery of ideation, which will then continue to act and send out more or less of expressive efferent impulses. Thus, a single frightful sight may give rise to prolonged feelings of terror, which in turn are expressed through various efferent channels for a long while.

In the *first class* of reflexes, consciousness and volition never enter.

In the *second class*, consciousness and volition may attend the inception of the process, but not necessarily, or generally, the rest of it.

In the *third class*, consciousness is always, in normal conditions, present, and acts of volition generally modify the play of afferent and efferent impulses.

In hypnotic conditions the mental state is made up entirely of the reflex phenomena described above, entirely undisturbed by volitional interference.

2. The nervous system is a mechanism for liberating, and at the same time co-ordinating and regulating, the various special energies or functions of the body. That it may do this more perfectly, and perhaps for other reasons, the brain, with its highly complicated powers, is developed. This nervous system seems capable of bringing into activity (or making kinetic) a certain amount of energy, which is normally distributed throughout the nervous system, more or less equally. Thus, it can at once move muscles, and can keep all the special senses and the mind itself moderately active. We can walk about, can see, hear, feel, and think at nearly the same moment. But it cannot make any of the special functions of the body particularly active, it cannot lib-

erate nervous energy largely in one particular direction without the other parts suffering. While watching intently, we cannot feel, or taste, or hear with any great degree of perfection. While reflecting deeply, the special senses are somewhat dulled. If the nervous system is busy in sending out powerful or delicately adjusted motor impulses, its other duties are somewhat neglected. I am only expressing, in physiological language, the very commonplace fact that we can only do one thing well at a time. And, furthermore, that we have the power, by exercise of our will, of directing the nervous energies almost exclusively in one or two directions. That is to say, we have the power of concentrating the attention and our muscular movements.

Now, this mobility, so to speak, of the nervous or mental energies, this capacity of being turned into one channel and acting very powerfully there, is most conspicuously brought out in the phenomena of trance. It is a leading characteristic of the state, as was shown by Dr. George M. Beard.

Morbid Anatomy.—The underlying changes of the hypnotic condition are unknown, and will probably long remain so. Hypnotism is no doubt associated with changes in the vascularity of different parts of the brain, and with rapid breaking down of nerve tissue. Animals constantly subjected to hypnotic influence become demented (Harting, Milne-Edwards).

Diagnosis.—As hypnotic states may be imitated, and as injuries or crimes may be done during this state, it is very important to be able accurately to distinguish it. Since the phenomena are all subjective, this is very difficult. The methods of value are these: 1. Careful examination of the general phenomena by experts while the subject is in the alleged hypnotic state. 2. Testing the muscular hyperexcitability by percussing motor points. 3. Tests of alleged anæsthesia by sudden burning, or pinching, or injuring the subject. 4. Tests of the tetanic muscular rigidity by the revolving tambour. In the hypnotic state the hand may be extended and held with perfect steadiness, while in conscious states a tremor soon appears. 5. Tests with glasses and other apparatus may be made to determine alleged anæsthesiæ of the special senses.

V. The Hyperhypnoses.—*Drowsiness, Morbidly Prolonged or Profound Sleep, Narcolepsy, Abnormal Attacks of Sleep, Lethargy, Coma, Carus, Cataphora, the Sleeping Sickness.*—Persons may be subject to sensations of drowsiness which continue with them nearly the whole of the day, or come on at certain times during the day.

Other persons sleep too profoundly, or too long.

Again, certain individuals are attacked suddenly with a desire to sleep, which they cannot resist. These paroxysms come and go like epileptic seizures, and they may even take the place of such seizures. Sometimes these paroxysms simply affect the sleep at night. The person goes to bed, but can with difficulty be awakened the next day, and if left unmolested, he sleeps till noon or later. Such phenomena may be repeated for several successive days.

Finally, cases occur in which persons pass into a state of apparent sleep, which lasts for weeks or months.

These different states will be discussed under the heads of:

1. Morbid drowsiness.
2. Morbidly deep sleep.
3. Paroxysmal somnolence, narcolepsy, and epileptic somnolence.
4. Hysterical or trance sleep.
5. We have besides, symptomatic morbid somnolence, from organic brain disease, including the sleeping sickness of Africa.

1. *Morbid Drowsiness.*—This is a very common symptom, which may be due to any one of the following causes: 1. Old age, when there is a weakened heart or diseased arteries, with cerebral mal-nutrition. 2. The diseased vascular conditions which precede cerebral hæmorrhage. 3. The cerebral mal-nutrition or inflammations occurring before or during certain forms of insanity. 4. Various toxæmiæ, *e.g.*, malarial, uræmic, cholæmic, and syphilitic. 5. Dyspepsia and gastric repletion. 6. Diabetes. 7. Obesity. 8. Insolation. 9. Cerebral anæmia and hyperæmia. 10. Exhausting diseases. 11. Concussion of the brain. 12. Climatic conditions, cold, etc.

A very common cause of drowsiness is dyspepsia attended with some torpidity of the liver, the condition popularly known as "biliousness." Another frequent cause is malarial infection, which perhaps acts indirectly by impairing the functional activity of the liver.

Drowsiness from these causes oftenest comes on in the afternoon.

Anæmia is attended with drowsiness during the day, while there is often insomnia at night.

Syphilis is more likely to cause insomnia, but in its third stage somnolent conditions may be produced which are of serious significance.

Drowsiness occurs from the effects of severe cold. It sometimes develops when persons change their surroundings, especially on going to the seashore, for low levels and a high degree of atmospheric pressure seem to promote sleep. The drowsy state that sometimes follows concussion of the brain is a familiar phenomenon.

Some persons, no doubt, acquire the habit of drowsiness. At first the trouble may have been induced by indigestion, "biliousness," or malarial infection, but it persists after the cause is removed. Such persons can hardly sit through a lecture, a church service, or any exercise requiring quiet and attention. As the morbid drowsiness here described is only symptomatic, its treatment need not be discussed. Such remedies as coca, coffee, tea, atropia, glonoin, do not produce results equal to expectations.

2. *Morbidly Deep Sleep.*—Certain persons, when they sleep, pass into an almost lethargic slumber. In this state the spinal centres do not appear to share, but are abnormally excitable, from the lessening of cerebral inhibition. Consequently emissions occur, or there is nocturnal enuresis. As we have already stated, it is believed by some that sleep-drunkenness and even somnambulism occur in those states of morbidly deep sleep. Persons who sleep in this way often sleep a longer time than normal. They are awakened with difficulty, and then suffer with headache or disagreeable sensations throughout the day.

This disorder of sleep is most liable to occur in the young and in those of nervous temperament. It often seems to be a congenital condition, for which nothing can be done. In other cases it results from over-feeding and indolent habits. Treatment is much the same as that indicated for sleep-drunkenness and somnambulism.

The following case, described to me by Dr. Sibert, of South Hill, Ala., illustrates this type: A married woman, aged twenty-eight, of good family history and in good health, except for some anæmia from lactation, had suffered from excessive sleep since six years previously, when she was first confined. The hyperhypnotic state was manifested only during the night, and only as a profound slumber, from which it was exceedingly difficult, even by the roughest handling and the infliction of pain, to arouse her. There was no history of vascular, digestive, or cerebral disorder. It was thought that the condition was due to cerebral anæmia, induced by protracted nursing, but the difficulty was not worse during lactation than it was during the intervals. She improved after weaning her child, under blood and nerve tonics.

Instances in which persons retire at the usual hour, but can with great difficulty be roused in time for the ordinary duties of the day, are not rare. Some of these are illustrations of the vice of indolence, but in other cases there is an absolute need of nine, ten, or even fourteen hours of sleep. Here is a case in point: A young officer, otherwise healthy, could not possibly get along without fourteen hours of sleep. He slept until noon every day and lost his commission in consequence (Quoted by T. More Madden: *Dublin Journal of Medical Sciences*).

Some cases of this kind, it should be remembered, are prodromal of insanity.

3. *Paroxysmal Sleep, Narcolepsy, Sleep-epilepsy.*—It sometimes happens that persons suffer from sudden at-

tacks of unconquerable drowsiness; they fall off into slumber despite every effort of the will. These are more than drowsy sensations, for sleep, or a state resembling it, cannot be kept off. Some of these cases are of a purely nervous character, *i.e.*, the trouble is not due to a humoral poison or to organic disease, but to a paroxysmal change in the nervous centres, of a vascular or chemical character, causing sleep. It may be that the patient is epileptic and the sleep-seizure takes the place of the ordinary epileptic spasms. An illustration of this is the following:

The patient was about twenty years of age, and had been subjected for a couple of years to attacks of falling asleep for a few minutes in any position, often while standing, and when not tired. There did not appear to be anything pathological about them except their occurrence when the patient was not tired. She married at about the age of twenty-two or twenty-three years, and then began to suffer from infrequent, well-marked epileptic attacks. Her brother subsequently was found to be also suffering from epilepsy. The patient herself appeared to be entirely healthy in all other respects (L. Putzel).

Other cases are illustrations of a pure sleep neurosis or narcolepsy, as described by Gelineau. A case in point is the following:

The patient was a man aged thirty-eight. Family and early personal history good. No syphilis. Married, and had two children. Moderate drinker. Had had acute articular rheumatism. Three years ago had a fight and a fall. Two years ago his symptoms began. He would fall asleep whenever he undertook to eat, walk, or go to the theatre. Anything particularly exciting his attention would throw him into a sleep. He would sleep a little, then wake. He had one or two attacks daily, accompanied by dizziness. He often had attacks of dizziness. Intelligence, memory, and consciousness were not lost during the attacks (Gelineau: *Gazette des Hôp.*, July 8, 1880).

While Gelineau's case might have had something of a hysterical or mesmeric element, the following is quite free from such causes. It was apparently neurasthenic in origin:

The patient was a physician who had suffered from this condition for fifteen years. He was habitually overcome by an uncontrollable desire to sleep during the daytime, no matter how *mal apropos* the time or place; this desire he would fight against with all his power of control, but would finally yield to sopor. Even in the dentist's chair, while a sensitive tooth was being "scraped," he had fallen asleep. Often in the rounds of daily practice he would feel this lethargy creeping over him at critical moments, as, for instance, when his services were most needed at confinements, and would be forced to yield to it and sleep. It was impossible, for the same reason, for him to read for but a short time, and he had been obliged to abandon study and mental work entirely. He had other symptoms of brain exhaustion, such as forgetfulness, frontal headache, etc. There was no evidence of organic disease (W. J. Morton).

Cases of epileptic sleep, narcolepsy, and allied forms are not of frequent occurrence. Females are rather more often affected than males, and the susceptible age is from fifteen to forty. The disorder is brought on sometimes by fright, over-strain, and humoral poisons acting on a predisposed nervous system.

The course is chronic, and relief is not always obtained. It should be remembered that syphilis, malaria, or anæmia, and indigestion may be elements in the trouble which are important, if not fundamental. Bromides are often useful factors in treatment. Change of occupation, of mode of life, or of climate, may be essential to a cure.

4. *Hysterical, Cataleptic, or Trance Sleep, Lethargy.*—Most of the so-called cases of prolonged sleep, lasting for days or weeks, are cases of spontaneously developed mesmeric sleep in hysterical women, or cases of incipient insanity (katatonia or stuporous melancholia). The phenomena in these cases may take almost any of the forms of the mesmeric condition. The patient may be cataleptic, or lethargic, or in a somnambulic condition. The mental state is essentially the same as that in hypnotism, and, though reported as cases of prolonged somnolence, as sleeping girls, etc., these really are to be classed among the parahypnotic.

The subjects of trance sleep are mostly women. Among 26 cases collected by myself, the males were 5; females, 21. The age ranged from sixteen to thirty-two.

Trance sleep shows itself in several ways:

Thus there is a set of cases of trance lethargy so-called, in which the patients are plunged into a deep and prolonged unconsciousness, lasting from one day to several years. These are "sleeping girls," and fasting girls.

Another class includes those who apparently are the victims of a too ready susceptibility to mesmeric suggestion, or who get into a morbid habit of going into mesmeric sleep spontaneously.

A third class includes the patients who suffer from somnolence or drowsiness in other irregular forms. These patients are evidently hysterical, but their somnolent symptoms appear in peculiar ways.

In these states there may be a lowering of bodily temperature, slowing of respiratory and heart action, and excessive sluggishness of the action of the bowels. The patients can hear and may respond to suggestions, but they are apparently insensible to painful impressions, and do not appear to smell, taste, hear, or see. The eyes are closed and turned upward, and the pupils contracted as in normal sleep. Many variations, however, occur in the physiological phenomena of these states.

The duration of the attacks of trance lethargy is from a few hours to ten years (case of sleeping girl of Trouville, *Lancet*, June, 1881). Ordinarily, however, profound trance sleep lasts not more than a few days, while those cases in which the sleep is from mesmeric suggestion last but a few hours.

Cases illustrating the above types are here given:

Case I.—A woman, aged twenty-four, large, well formed. At the age of eighteen she fell into a trance sleep lasting forty days; at the age of twenty another attack lasted fifty days. All the latter time she was insensible, could not be roused, and had to be fed. When twenty-eight years old she fell into another lethargy, which lasted several months. The respiration was very shallow, pulse slow, organic life at a low ebb (M. Blondet: *Gaz. hebdomadaire*, October 28, 1864, p. 726).

Case II.—A young lady, aged seventeen, while in church was suddenly seized with a desire to sleep. She went home, went to bed, and slept three days. No catalepsy. She awoke, was well for a month; then went into a sleep again (Lasègue: *Gaz. des Hôp.*, January 3, 1882).

Case III.—Mrs. M., aged thirty-two, mother of six children, of good family and personal history. Had had no symptoms of hysteria. Six weeks after confinement she suddenly fell into a trance sleep, which lasted for several months. Reflexes were not quite abolished at first, and she could then swallow food. Later she had to be fed. She slept within her trance, *i.e.*, at night she would snore. No cataleptic or other rigidity. She had some color (W. T. Gairdner: *Lancet*, December 22, 1883; January 5 and 12, 1884).

Case IV.—Lasègue cites the case of a young lady who used to fall asleep at 8 P.M. precisely, no matter what she did or how much she slept at other times; also the case of a Belgian countess, who for two years fell asleep daily at 9 P.M., no matter what she was doing.

Under this head of mesmeric sleep, I would refer to the curious facts of sleep following some mechanical irritation. I have known a young man who would fall into apparent sleep whenever a cleansing solution was thrown into his antrum. Dentists can relate many instances of unconquerable somnolence in patients on whom they are operating by no ordinary soporific methods.

5. *Morbid Sleep from Organic Disease.*—Prolonged and excessive sleep occurs as the result of syphilis of the brain, brain tumors, and the degenerative changes in old

age and insanity. Morbid somnolence and stupor are not very frequent in cerebral syphilis, but are quite characteristic. The patient in some cases lies or sits all day in a semi-soporous state; in other cases he walks about, but continually falls asleep at his task. This state of partial sleep may pass off or end in complete stupor (Wood). It does not necessarily signify a serious issue, even though it last for weeks.

Somnolence or sleep is a rare symptom in cases of cerebral tumors other than syphilitic. Conditions of drowsiness or stupor have been noted especially in tumors of the corpora quadrigemina, and the parietal lobes (Putnam-Jacobi).

Organic diseases of the brain tend to produce conditions of mental weakness, hebetude, or comatose states, rather than anything allied to sleep.

The Sleeping Sickness, Sleeping Dropsy, Maladie du Sommeil.—This is a peculiar disorder apparently infectious in character, which occurs among the negroes of the western coast of Africa. The disease has been transported to other regions, but is endemic only in Africa. It begins gradually with some headache and malaise. Soon there is felt a drowsiness after meals. This increases until the patient lies for nearly the whole time in a stupor. When awake he is dull and apathetic. There seems to be no fever, and the temperature may even be subnormal; the pulse, too, is not rapid; the skin is dry, the tongue moist but coated, the bowels regular. The eyes become congested and prominent. The cervical glands are enlarged. The disease ends in coma, and finally death. Recovery rarely occurs. Sometimes the course of the disease is more violent, and toward the end there are epileptic convulsions and muscular tremors. Autopsies have revealed no definite pathological changes. The history of the disease has been given by Clark, "Trans. of London Epidemiolog. Society;" Guérin, De la Maladie du Sommeil, 1869.

Accidents of Sleep.—Owing to the fact that sleep is a resting state of the organism, and that many of its functions are lowered, or their cerebral control lessened, peculiar crises, or physiological and pathological disturbances of nervous equilibrium occur. Attacks of gout, of asthma, and of pulmonary hæmorrhage are most liable to occur during the early morning hours. Deaths and suicides occur oftener in the forenoon, but births oftener at night. Epileptic and eclamptic attacks occur with much frequency at night. Involuntary emissions of spermatic fluid, orgasmic crises, incontinence of urine, are among the pathological incidents of sleep.

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SMALL-POX. Synonyms: Latin, Variola; French, Petite vérole; German, Pocken.

Definition.—Small-pox is an acute febrile, eruptive, contagious disease, the product of a specific poison in the blood of a patient suffering from this malady. It is generated solely by means of a specific virus, and is communicated by this virus from one individual to another after direct or indirect contact. The exanthem of small pox passes through four stages, namely, papule, vesicle, pustule, and scab, and usually leaves the face permanently scarred. The disease runs a definite course, and cannot be cut short by medicines. One attack of variola usually destroys the susceptibility of the individual to the disease during the remainder of his life.

History.—Small-pox, by reason of the malignant nature of the poison, and the general susceptibility to it of individuals of all ages, races, classes, and conditions, is the most loathsome and fatal disease known to man. It is a very ancient malady, though its origin is unknown. It is no part of the purpose of this treatise to enter into an exhaustive examination of the question as to when variola first appeared among mankind. De Haen, Willan, Moore, and Barron, contend that it was known to the ancient Greeks and Romans; while, on the other hand, Friend, Mead, Good, and Adams, insist that the ancient Greeks and Romans were unacquainted with it. Rhazes, an Arabian physician, who practised medicine about the year 910 A. D., was one of the most celebrated of the earlier writers on small-pox. The natural history of the disease was delineated by him with remarkable perspicuity when we consider the date of his writings and the status of medical knowledge at that time. Rhazes contends that Galen was familiar with variola, and quotes extracts from his first, fourth, ninth, and fourteenth books as evidence of the fact. He says: "As to any physician who says that the excellent Galen has made no mention of the small-pox, and was entirely ignorant of this disease, surely he must be one of those who have either never read his works at all, or who have passed them over very cursorily." Rhazes mentions Ahrun of Alexandria, and Mesue of Bagdad, among other previous writers on small-pox. Variola cannot be positively traced to a period anterior to the Christian era. Since its first appearance among mankind small-pox has never disappeared, and from Europe and Asia has been carried to the uttermost parts of the inhabited world. Small-pox existed in England in the first part of the thirteenth century, and in Germany in the latter part of the fifteenth century. From Europe the disease was brought to the United States soon after the discovery of America. It appeared in Mexico in 1527. Wherever it has existed it has been the greatest scourge of mankind. For centuries prior to Jenner's discovery of vaccination in 1798, small-pox had been regarded as the king of fatal diseases. M. de La Condamine says that small-pox was the cause of one-tenth of all the deaths among the human race. He further says: "Among those who outlive it many either totally or partially lose their sight or hearing; many are left consumptive, weakly, sickly, or maimed; many are disfigured for life by horrid scars, and become shocking objects to those who approach them. Immense numbers lose their eyesight by it." Half a million deaths were annually caused in Europe from small-pox prior to the discovery of vaccination. Macaulay, in speaking of small-pox in England, says: "The havoc of the plague had been far more rapid, but the plague visited our shores only one or twice within living memory, but the small-pox was always present, filling the church-yards with corpses, leaving on those whose lives it spares the hideous traces of its power, turning the babe into a changeling at which the mother shuddered, and making the eyes and cheeks of the betrothed maiden objects of horror to her lover."

Rosen says that in Sweden one-tenth of all the deaths

were from small-pox. We are assured that this disease concurred with fire and sword, and famine and blood-hounds, to complete the depopulation of Santo Domingo.

In the sixteenth century small-pox fell upon Mexico, and in a few years three million five hundred thousand of the population yielded up their lives to it, leaving in some places scarcely enough people alive to bury the dead. Brazil, in 1653, was invaded by small-pox, and in some instances whole races of men were carried to their graves by it. The Province of Quito, in a few years, lost one hundred thousand of her Indian population by this one disease. In 1707 Iceland was invaded by small-pox, and desolation and ruin followed in its wake for years, causing in that year the death of eighteen thousand out of a total population of fifty thousand. The fearful fatality of the disease is evidenced by the following extract: "In one island they found one girl, with the small-pox on her, and her three little brothers; the father having first buried all the people in the place, had laid himself and his smallest sick child in the grave, raised with stones, and ordered the girl to cover him." Greenland, in 1734, lost more than two-thirds of her population by small-pox. We are told, also, that one-sixth part of the inhabitants of Ceylon died of small-pox during one epidemic. Siberia has an equally lamentable history, and Kamschatka has also suffered severely from this terrible disease. One-tenth of all deaths in France, prior to the discovery of vaccination, were from small-pox. This country has been most cruelly and fearfully scourged by small-pox, the details of which must be too well known to need repetition here; whole tribes of our Indian population were swept out of existence by it. Europe, in the century preceding the discovery of vaccination, lost in deaths from small-pox 50,000,000 of her population. But it is unnecessary to continue the recital of such details. Enough has been presented to justify Macaulay in calling small-pox "the most terrible of all the ministers of death." Whenever and wherever it appeared in the past, in a community unprotected by vaccination, it was, as so well described by Alexander McKenzie, "as a fire consuming the dry grass of the field. The infection spread with a rapidity which no flight could escape, and with a fatal effect which nothing could resist." This disease had but one feature which was not repulsive; that one was that it was no respecter of persons. Reaching to the royal throne of France it laid Louis XV. in the grave. In Mexico it treated the Emperor similarly. In England it invaded the household of William III., killed his wife Mary and several others of his family, and would not leave the palace until it had attacked the king and maimed and disfigured him for life. The hovel of poverty was in this respect the equal of the palace of wealth, for small-pox was the terror of every household.

Long-suffering mankind eventually became hopeless of escape from the dread monster. When civilized man was thus hopeless, need we wonder that the untutored savage despaired also? McKenzie says of the Indians: "It was not uncommon for the father of a family whom the infection had not reached, to call them around him, to represent the cruel sufferings and horrid fate of their relations, from the influence of some evil spirit who was preparing to extirpate their race, and to incite them to baffle death, with all its horrors, by their own poniards. At the same time, if their hearts failed them in this necessary act, he was himself ready to perform the deed of mercy with his own hand, as the last act of affection, and instantly to follow them to the common place of rest and refuge from human evil."

After centuries of havoc from small-pox variolous inoculation was introduced, and the mortality was in consequence greatly lessened.

Inoculation.—In no field of human research can a more curious phenomenon be found than is shown here. That a man should be compelled to take small-pox in order to save his live is surprising indeed, but such was the intention, and the wonderful reduction of mortality among the individuals so treated fully testified to the propriety of the measure. Inoculation is the placing of the virus of small-pox, by puncture, under the skin, in the blood of the subject inoculated. The purpose of inoculation was to produce a modified form of small-pox which would afterward confer upon the subject so treated exemption from a malignant attack. This weapon is of great antiquity. Kirkpatrick says of it, "Some poor, unlearned, but heaven-taught mortal, some Chinese, Hindoo, or Circassian, first hit upon it." It is admitted to have been practised for a long but unknown number of years in Hindoostan. The Chinese had for hundreds of years used crusts or scabs of small-pox, placed in the nose, for the purpose of inoculation. Of inoculation, in 1717, the wife of the English Ambassador to the court of Turkey, writing to her home, says, "The small-pox, so fatal and general among us, is here entirely harmless by the intervention of engrafting, which is the term they give it. Every year thousands undergo the operation, and the French Ambassador says pleasantly, that they take the small-pox here by way of diversion, as they take the waters in other countries. There is no example of any one who has died of it." Dr. Simon says of this measure, "to the present time it remains one of the most interesting and least explained facts of pathology that the specific contagion or ferment of small-pox, so uncontrollable in its operations when it enters a man in the ordinary way of his breathing an infected atmosphere, becomes for the most part disarmed of its virulence when it is artificially introduced into the system through a puncture of the skin." By resort to inoculation the mortality among those so treated was reduced from one death in every three cases of natural small-pox, to one death in every three hundred cases of inoculated small-pox. Some authorities give the protective powers of inoculation as representing one death in every one thousand cases. Thus it will be seen that the practice of inoculation offered to the individual, doomed to take small-pox, a far greater security against death than any measure in use prior to the introduction of vaccination. While the security against death to the individual in whom small-pox was inevitable was most wonderfully augmented by inoculation, yet to the country at large the practice of variolous inoculation was a curse instead of a blessing—for inoculated small-pox lost none of its fatal power of conveying malignant variola to all unprotected persons. The Royal College of Physicians of London, in 1807 (report on vaccination) says, "However beneficial the inoculation of small-pox may have been to individuals, it appears to have kept up a constant source of contagion, which has been the means of increasing the number of deaths by what is called the natural disease." Dr. Heberden says that, in the first thirty years of the eighteenth century, before inoculation became general, the deaths from small-pox to every 1,000 deaths were 74; for an equal period during the general practice of inoculation, at the end of the eighteenth century, the deaths from small-pox were 95 to 1,000 deaths—an increase in the proportion of 5 to 4. After the discovery of vaccination, it being so much superior to inoculation, the latter practice was made unlawful.

Vaccination.—Of this weapon of defense against small-pox, Simon, after speaking of the mysterious effects of inoculation, says of vaccination: "Equally strange and inexplicable is the further and greater change which this ferment undergoes in passing through the textures of a cow; a change which renders it incapable, when retransplanted to the human system, of any longer propagating itself by effluvia, while it retains its capability of propagation by inoculation, and its power of protecting the system against its own further action thereon."

Vaccination differs entirely in purpose and value from inoculation. The objects of vaccination are: 1, Prevention of small-pox; 2, control of that disease when prevention is not obtained. As already seen, the only purpose or value of variolous inoculation was the mitigation of the severity of small-pox in the subject inoculated.

Vaccination will be briefly considered in the latter part of this treatise.

Etiology.—Small-pox is disseminated by breathing an atmosphere infected with the virus, by contact with an

infected person, clothing, bedding, etc., or by direct inoculation of an unprotected individual. It is a disease *sui generis,* and can be propagated solely by its own specific virus. The poison of variola resides in the exanthem, the breath, and the exhalations of the body. Attempts to produce the disease by vaccinations with the blood and secretions from the body of a small-pox patient have resulted negatively. Variola is transmissible by inoculation with the contents of the pustule; but the pus of a small-pox pustule may be rubbed on the skin of an unvaccinated person without producing the disease, unless the skin has been abraded. If, however, the matter from the pustule be brought in contact with the mucous membrane, variola will almost certainly be contracted. The disease may be transmitted to persons who have never been in immediate contact with small-pox patients or with infected materials. Competent observers claim that the disease may be disseminated over a city through the medium of the atmosphere. I have never observed any fact tending to confirm this statement. Cases are recorded in which the disease has been contracted when individuals have never approached nearer than within three feet of the small-pox patient in the open air. The virus of variola is tenacious of life; it is not always killed by the process of drying, and when protected from the atmosphere has been known to retain its vitality for years. The poison clings to clothing, bedding, etc., and will remain active for a long time in these articles if they are not chemically disinfected or exposed to the disinfectant power of the atmosphere. The disease is therefore portable. The virus of small-pox enters the system by absorption through the mucous membrane of the respiratory tract. The effect of the poison of variola, as to the lightness or severity of symptoms, varies with the constitutional condition or degree of susceptibility of the individual. If an unvaccinated person be exposed to varioloid he may contract malignant small-pox, and, on the other hand, an individual who has never been vaccinated may be exposed to malignant variola and only take varioloid. This inequality of individual predisposition has been observed from the earliest period of the written history of the disease. A small fraction of mankind seems to be wholly insusceptible to small-pox. Every practitioner of experience has met with occasional instances in which unvaccinated individuals have been repeatedly exposed to variola and yet failed to take it. I have known two physicians who could never be successfully vaccinated, notwithstanding repeated efforts to inoculate them with vaccinia. These physicians have on several occasions attended cases of small-pox and failed to take the disease. These instances of individual insusceptibility to vaccinia and variola are among the rare experiences of medical practice, and only serve to illustrate occasional exceptions to the rule of well-nigh universal susceptibility of the human race to both diseases. Some few individuals evidence a remarkable susceptibility to small-pox. While in the vast majority of persons one attack of the disease is fully protective against a second one, yet there are some few who have had several attacks of variola. Well-authenticated cases have been recorded in which individuals have had as many as four attacks of small-pox. I have seen only four cases of second attacks of variola, two of which proved fatal. In the latter instances a long number of years intervened between the invasions, but in each person the face was badly "pock-marked" by the first attack. As a general rule, a subsequent attack of variola in the same individual runs a mild course, though in some instances it is more malignant than the first one.

A successful vaccination generally protects the individual against small-pox during life, though the exceptions to this rule are numerous, and therefore revaccination should be universally practised. If a person has been successfully vaccinated in infancy or childhood, revaccination should be practised at puberty. Nothing definite is known as to the exact nature of the small-pox poison. Much speculation has been indulged in by the pathologists on this point, but every investigator has failed to solve the problem. Cohnheim and Weigert claimed that the micrococci in the vesicles are the specific contagious elements of variola. We have no satisfactory proof that either vegetable germs or bacteria constitute the essential elements of the disease. Much difference of opinion exists among practitioners as to the earliest time at which a small-pox patient can infect an unprotected person. Many believe that the poison is given off during the primary fever; others that it becomes active during the suppurative period, and this opinion is generally entertained by the profession; there are, however, a few practitioners who claim that it occurs at the period of desiccation.

Morbid Anatomy.—The description of the lesions of small-pox by Loomis ("Practical Medicine") is of such excellence that I have taken the liberty of quoting it entire in this section: "Besides those anatomical lesions which occur upon the mucous membranes and skin, there is more or less intense congestion of the lungs, brain, liver, spleen, and kidneys. In the hæmorrhagic form of small-pox small hæmorrhages occur in nearly all the viscera, with ecchymoses in the serous membranes, and blood-stained fluid in the serous cavities. The mucous membrane of the stomach and rectum is oftenest the seat of these extravasations.

"The characteristic anatomical lesion of small-pox is to be found upon the mucous membranes and upon the skin. This lesion is usually spoken of as the eruption. It does not differ essentially in the different varieties; the modifications which are met with are due rather to its duration and the order of its development. These surface lesions pass through regular stages of development and decline.

"The first step in the formation of a small-pox pustule is congestion of the skin in discrete spots; the vessels of the corium are dilated and tortuous, and the connective tissue of the papillæ, in the centre of the congested zone, shows more or less œdema. The non-elevated red spot (looking at first like a flea-bite) is a macule. Next, the skin is elevated at these (macular) points and a papule forms, from changes in the cells of the rete Malpighii. Soon the papule becomes a vesicle; in its centre the epidermis becomes distended with serum and cells. As the effusion increases the cells change; the horny layer above is raised, and the summit of the papule becomes the centre of the vesicle. The changed cell elements are pressed, separated, and massed into groups from pressure of the effusion, and a stringy meshwork is formed in the vesicle. Meanwhile proliferation of the adjoining cells forms a peripheral wall for the vesicle, the contents of which soon become turbid.

"Umbilication of the vesicles now occurs. Trabeculæ slowly spread from roof to floor of the vesicle, and hold down its centre, while marginal cell-proliferation and the accumulation of serum bulge out its periphery. After the vesicles are fully formed, pus-cells appear in them, and, as a result, the vesicles change in color, and become pustules. At the same time an inflammatory process, more or less extensive, is going on in the walls of the pustule, and in the surrounding cellular tissue, which terminates in a destruction of tissue at the point where the papillary congestion first occurred. If only the superficial layer of the skin is involved, the infiltration of pus-cells into the vesicle and the formation of the pustule may take place without extension of the inflammation into the cellular tissue beneath, and necrosis or death of the part will not follow; but if the inflammation extends into the deeper tissues, a slough will be produced, which necessarily will be followed by a cicatrix and pitting. After the pustule is formed the inflammatory products begin to dry down, and a crust is formed which contracts in the central portion, and the same umbilicated appearance is presented that is seen in the umbilicated vesicle. The incrustation begins at the centre. The crusts are made up of dried pus-cells and detritus. After a time these crusts are separated by the ordinary changes which occur in the subsidence of an inflammatory process, and recovery is complete, except that there is left behind a cicatrix like that formed under any other circumstances. These pustules may be formed upon any mu-

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cous membrane. They occur oftenest in the nose, mouth, trachea, bronchial tubes, and larynx.

"There is nothing specific or essentially different in the development of the pustules in hæmorrhagic small-pox, except that they contain blood instead of serum or pus. In the hæmorrhagic variety larger or smaller hæmorrhages take place into the cellular tissues and into the cutis; in the milder forms they take place only in the layer beneath the papillæ, while in the severer forms they take place beneath all the cutaneous layers; even the subcutaneous fat may be infiltrated with blood. No changes in the walls of the vessels have as yet been discovered which will account for these hæmorrhages. These extravasations most frequently occur in those cases in which death takes place before the period of pustulation is reached. In hæmorrhagic variola blood extravasations occur into the substance of all the organs, the marrow of the bones, and on mucous and serous surfaces, and infarctions in the lungs are the rule. Hyperæmia and œdema of the brain sometimes occur."

Symptoms and Course.—During the period of incubation, which is ordinarily nine days in inoculated small-pox, and fourteen days in the non-inoculated variety, the health of the patient is about as usual.

The first stage of variola is ushered in with a chill, high fever, severe head-ache, and intense pain in the lumbar and sacral regions. The chill is more violent than is witnessed in any other eruptive disease. The temperature reaches 102° F. to 103° F. on the first day; on the second day 104° F., and on the third day the thermometer may indicate 106° F. With the elevation of temperature the pulse becomes full and frequent, beating from 120 to 140 or 160 per minute. The patient complains of nausea, vomiting, sore throat, and photophobia. The high fever and severe constitutional disturbance cause great restlessness and occasionally delirium. Convulsions not infrequently occur in children. The face is flushed, the conjunctivæ are congested, and the carotid arteries throb violently. By the end of the second day redness and swelling of the tonsils and soft palate are observed. The redness and swelling may extend into the larynx, when hoarseness with stridulous cough occurs. The initial fever and the constitutional perturbation reach their greatest height by the end of the third day, when the eruption begins to show itself. The prodromal symptoms are usually very severe, but the intensity of the initial symptoms is not always indicative of the severity of the attack, for it is occasionally observed that the prodromal symptoms of mild cases are of considerable violence. During this period in the history of the disease there are no symptoms present by which a diagnosis of variola may be positively made, for there are no characteristic affections of the mucous surfaces in the prodromal stage of variola, such as may be detected in the initial stage of scarlet fever or of measles. The violent pain in the sacral and lumbar regions is, however, so characteristic of variola that we should suspect the existence of the disease when it is present.

Stage of Eruption.—On the third day from the commencement of the initial fever the exanthem begins to appear on the face, scalp, and neck. When the eruption first makes its appearance it is in the shape of slightly elevated papules about the size of millet-seeds, and of a reddish color. Whenever the exanthem is copious the red spots lie close together and almost unite with one another, resembling the eruption of measles, and the disease is liable at this stage to be mistaken for measles. Usually within twelve hours after the papules have appeared on the face they extend to the trunk and limbs, though the eruption on these parts is not so copious as on the face. The eruption on the mucous membranes generally begins at the same time as upon the skin, but, in consequence of the slight disturbance it at this time produces, is frequently not detected. The papules in the mouth soon cause increased flow of saliva, in the pharynx difficulty in swallowing, in the larynx hoarseness and cough, and on the conjunctivæ lachrymation and photophobia. By the end of the first day of the efflorescence the papules become larger, have a more livid color, and to the finger passed over them impart a sensation as if there were shot beneath the skin. These papules gradually enlarge, and on the third day become vesicular. The vesicles soon become umbilicated and contain a lactescent fluid.

Stage of Suppuration.—By the sixth day of the efflorescence the vesicles begin to lose their umbilicated appearance, assume a globular shape, and become turbid from admixture of purulent matter. By the eighth day the pustules are fully matured. The skin surrounding the eruption becomes red, swollen, and œdematous; each pustule has a broad base, and in case of confluent or semi-confluent small-pox is closely set against, or runs into its fellows. During this stage the patient suffers from profuse salivation, swallowing is accomplished with great difficulty, the nose is plugged up with pustules, the voice is husky or inaudible, the cough croupy and distressing, and there is marked dyspnœa; the eyes are red, discharging muco-pus, and are extremely sensitive to even a faint light. When the exanthem covers the face it is swollen into a shapeless mass, the eyes are closed, and the features of the patient are unrecognizable. No more repulsive sight can be witnessed than that of a patient in this stage of variola. The eyes, nose, lips, ears, cheeks, hands, feet, and genitalia, present one mass of horrid deformity. The suppurative or secondary fever comes on with the maturation of the pustules. A chill ordinarily precedes the secondary fever. This fever is distinctly remittent in type, reaching its greatest height in the evening. The temperature is usually higher than in the initial stage, and may reach 107° F. The pulse increases simultaneously with the temperature, ranging from 120 to 150 beats per minute. At this time the patient is in the most critical period of the disease; the high fever and constitutional perturbation continue until the stage of desiccation. The temperature and pulse begin to decline as desiccation commences, and when the crusts are being thrown off have about reached the normal. A subsequent marked elevation of temperature is indicative of some complication, such as erysipelas, pneumonia, etc.

Stage of Desiccation.—The process of desiccation ordinarily commences on the twelfth day, and is first observed on those parts of the body on which the eruption appeared earliest. The desiccative process usually occupies from eight to fourteen days, the length of time being governed by the degree of pustulation. Just prior to, or at the time of the beginning of, desiccation many of the pustules rupture, and the exuded fluid dries into hardened brown or yellowish crusts. This crust may be so extensive as to cover the entire face. As desiccation advances the swelling of the skin lessens, and the constitutional disturbance markedly subsides. Cicatrization of the pustules advances beneath the crusts, and the crusts are finally separated and thrown off, leaving the site of each of the pustules of a reddish-brown or violet color, with elevated margins and depressed centre. If the skin has not been deeply invaded these blotches gradually lose their abnormal color, leaving only shining white scars which sooner or later disappear; if, however, the skin beneath the pustules has been destroyed the face will be permanently pock-marked. By the time desiccation has been completed the patient is convalescent, and usually regains his former health within a month.

The above history is an outline of a typical case of variola discreta, and is the type most usually met with among the unvaccinated. It is unnecessary to attempt to present an outline of the history of each type of variola met with, and described by various writers. But three other types will be described, viz., variola confluens, variola hæmorrhagica, and varioloid.

Variola Confluens.—This type differs from the discrete variety in that the eruption and constitutional symptoms are much more severe than in variola discreta. Ordinarily the initial fever is much more violent than in the discrete variety, and is of shorter duration, usually lasting not more than two days. The initial fever frequently reaches 106° F. or 108° F. for a limited period of time, and then falls to 103° F. or 104° F. Likewise the development of the eruption in this type occurs from twelve to eighteen hours earlier, and spreads over the

body more rapidly, frequently appearing at the same time on the face, trunk, and limbs. The papules which first mark the disease are often so thickly set upon the face, scalp, neck, and hands on the first day of eruption that they run into one another. By the end of the second day the skin is intensely red and greatly swollen, and large flat vesicles rapidly develop and coalesce into large tracts of eruption. Suppuration rapidly ensues. The entire face has one continuous covering, the patient having the appearance of one wearing a mask. Notwithstanding complete coalescence of the exanthem on the face and hands, the eruption on the remainder of the body is usually either discrete or semi-confluent. Where the eruption on the body generally is confluent, there is scarcely any hope of the patient's recovery. Pustulation of more than one-fourth of the body will, as a rule, produce death. Confluent variola is a very fatal disease, the mortality ranging from fifty to seventy-five per cent. In the onset, and throughout the entire course of the disease, the confluent type shows a marked difference in the intensity of symptoms from the discrete variety. In addition to the more vehement fever and delirium the nervous and muscular systems show the greater depression of the vital powers. The mucous membranes are attacked with greater severity, the eruption in the mouth and throat is confluent, and frequently a diphtheritic exudation spreads over the soft palate, tonsils, posterior wall of the pharynx, and the nasal cavity. The larynx is usually invaded, and the marked severity of this complication is often evidenced by submucous abscesses, necrosis of the cartilages, or œdema glottidis. The eyes are more severely affected in this type, the eruption appearing thickly upon the lids, and the severe inflammation not infrequently results in keratitis with perforation. In the mouth the severity of the disease is manifested by profuse salivation, great difficulty in swallowing food or medicine, and not infrequently by inflammation of the parotid gland. Variola confluens is prone to a number of complications, such as bronchitis, pneumonia, pleurisy, pericarditis, diarrhœa, albuminuria, etc. The secondary fever is greater than in the discrete type, frequently reaching 108° F. Many patients succumb before the eruption makes its appearance, but the majority who die live until the stage of desiccation is reached—death resulting then from exhaustion or from one of the numerous complications which beset this type of variola. In those who live the process of desiccation is more slowly accomplished, and the face is horribly pock-marked. The hair is ordinarily destroyed and permanent baldness is a frequent sequel of this affection. Convalescence from variola confluens is tedious and protracted.

Variola Hæmorrhagica.—The difference between variola hæmorrhagica and the other types of small-pox is in the character of the eruption, and not in the initial fever nor in the constitutional symptoms. It is simply a modification of the other varieties of small-pox. The hæmorrhage into the eruption is observed to take place under various circumstances. In some cases the exanthem becomes hæmorrhagic upon the appearance of the papules, in other cases when the vesicular stage is reached, while in yet other cases, only when the pustules are fully formed. In some cases the entire eruption is hæmorrhagic, while in others one-half, or even a very small portion of the efflorescence, shows this complication. The hæmorrhagic eruption, as a rule, begins upon the lower limbs. Petechiæ and ecchymoses usually appear between the hæmorrhagic pocks, and livid spots or patches on the mucous membranes, particularly in the mouth and throat. Diphtheritic exudations frequently form in the tonsils, pharynx, and nasal cavity. The gums become spongy, and readily bleed as in scurvy. Hæmorrhages take place from the nose, stomach, lungs, kidneys, rectum, or uterus. The amount and persistency of the hæmorrhage vary with different cases. Prior to the appearance of the hæmorrhage, it is impossible to predict this form of small-pox. The initial fever is ordinarily mild, and throughout the subsequent course of the malady the temperature will rarely exceed 102° F.; when the hæmorrhage has been profuse the temperature falls below the normal. The contrast between the temperature and pulse-rate is marked; while the temperature is but little above, at, or below the norm the pulse is feeble, and beating from 140 to 160 per minute. The breathing is rapid, the countenance pinched and sunken, and occasionally there is delirium, but, as a general rule, the intellect remains clear to the end of the scene. This is a very fatal disease; the vast majority of patients die, death usually occurring on or before the fifth day.

Varioloid.—Varioloid is small-pox modified by a previous attack of vaccinia, a previous attack of variola, or by a degree of personal insusceptibility. There is no ground whatsoever for the old claim that it is essentially different from variola vera. Varioloid is milder in its course and shorter in duration than is the unmodified variety, and it presents many striking departures from a typical case of variola. The duration of the initial fever is usually two days; the temperature rarely reaches 102° F., falling ordinarily to the normal by the end of the second day. Occasionally the initial fever is as high as in unmodified small-pox. The secondary fever of variola is frequently absent in this type, and when it occurs is but slight, and continues ordinarily not more than twenty-four hours. The exanthem in its development and character differs markedly from that of variola. Unlike variola the eruption in varioloid usually appears simultaneously on the face, chest, and limbs. The exanthem rarely passes through all the stages usually witnessed in the unmodified variety; it may not progress beyond the papular stage, or it may, and usually does become vesicular; not infrequently it becomes pustular, but the pustules are dwarfed, and, while they are surrounded by a distinctly red areola, the skin is neither tense nor œdematous, and the pustules readily dry up. Desiccation usually commences from the fifth to the seventh day. The pitting usually resulting from variola rarely occurs after varioloid, though occasionally deep and permanent scarring of the face is witnessed. The eruption on the mucous membranes is but slight, and causes markedly less disturbance than in unmodified small-pox. When the exanthem passes through all the stages of variola the distinction between the two affections is to be found in the milder constitutional symptoms, and the smaller number of pocks in varioloid. The mortality from varioloid is very small.

Differential Diagnosis.—Until the characteristic exanthem of the disease appears it is impossible to make a positive diagnosis of small-pox. It is, of course, important to make a diagnosis as early as possible in order that the necessary sanitary precautions against the spread of the disease may be instituted. On the other hand, the physician should not be too hasty in making a diagnosis, for if he should arrive at an incorrect opinion the patient may be taken to a small-pox hospital and thereby contract the disease, when he would not have been subjected to such an unwarrantable risk had the medical attendant waited—as he should have done—until a positive diagnosis could have been made. In mistakes of this kind, which have not been infrequent in the history of medicine, the physician is, under the law, liable to pecuniary damages, and will suffer much detriment to his reputation for professional skill and acumen. There is no justification for undue haste in diagnosticating this malady. The medical attendant will have discharged his full duty by isolating the patient and awaiting the development of the stage of variola at which he can prudently decide the nature of the disease. How soon can small-pox be recognized? A practitioner who has had considerable experience in small-pox may occasionally be able to detect it the second day after the first appearance of the eruption, but such a diagnosis is always, and under all circumstances, unless there be knowledge of direct exposure of the person to variola, extremely hazardous, and the doctor who values his reputation will never be guilty of such rashness. At this stage of the affection there is nothing in either the initial symptoms or the exanthem by which he can positively reach a diagnosis. In the absence of a knowledge of direct exposure to variola the only prudent course is to isolate the patient and await

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the vesicular stage of the exanthem before expressing a positive opinion on the subject. The wisdom of this course is abundantly attested by the experience of the London Small-pox Hospital. Marson says on this subject: "Upward of twenty diseases have been mistaken within the past few years, in the early stage of the disease, for small-pox, and the patients have been sent as having small-pox to the small-pox hospital." Such mistakes show an appalling amount of ignorance or carelessness on the part of their authors, and should serve as warnings to practitioners who pride themselves on their ability to make an early diagnosis in variola. When the characteristic eruption has appeared there are but few diseases which are liable to be mistaken for small-pox. These diseases are: measles, varicella, pustular syphilis, and febrile lichen.

Diagnosis of Small-pox from Measles.—Prior to the vesicular eruption of variola it is liable to be mistaken for measles. If the physician awaits the time for the vesicles to appear, and under these circumstances he should invariably do so, such a mistake would be inexcusable. During the papular stage of variola the eruption of measles simulates that of the former. The catarrhal symptoms (bronchial, nasal, and conjunctival) of measles should suffice to point out to the doctor the probable nature of the disease, for these symptoms are invariably absent in the early stage of uncomplicated small-pox. The thermometer offers valuable assistance in making a diagnosis between these affections. In variola the temperature declines when the papular eruption appears, while in measles the thermometer shows that the fever continues to rise after the exanthem appears. Furthermore, the temperature of variola is ordinarily two or more degrees higher than that of measles. As a rule, the exanthem of small-pox appears on the third day, while in measles it appears on the fourth day. Then, too, the eruption of measles is more superficial, and is not so distinctly felt as in variola. The intense pain in the sacral and lumbar regions is so characteristic of small-pox that this symptom should cause the attendant to suspect small-pox.

Diagnosis of Variola from Varicella.—While some writers of the present day contend for the identity of variola and varicella, the great majority of the profession deny this assertion. In the whole range of medical science no proposition can be more clearly established than that varicella is a disease *sui generis*. The diagnosis of varicella from light cases of small-pox is often a perplexing and difficult problem. While they are essentially different diseases, they frequently prevail as epidemics at the same time, and, as the characteristic eruption of each affection closely resembles that of the other, the diagnosis of variola from varicella is a problem frequently presented to the physician for solution. The distinction between these diseases is well-defined, and by the exercise of care they should not be confounded. In varicella the initial fever is, as a rule, absent, but when it occurs it is very slight, while in variola it is invariably present and more intense than in the former. In varicella the initial fever rarely extends beyond twenty-four hours, while in the lightest cases of variola it lasts fully two days. Intense pain in the sacral and lumbar regions is almost invariable in variola, and absent in varicella. But it is in the character of the eruption that the most striking difference between the two diseases is manifested. In varicella the eruption has less hardness than in variola, and the shotty feel of variola is absent. Furthermore, there is but a slight red base, if any, to the pock of varicella, while in variola the red base is prominent and always present. The exanthem of varicella becomes vesicular within twenty-four hours from its first appearance as a papule, and it rarely proceeds beyond the stage of vesiculation, while in variola the eruption only occasionally stops with the development of the vesicular stage. Umbilication of some of the vesicles is observed in varicella, while in variola umbilication is found in nearly all the pocks. Again, the vesicles of varicella are much larger than in variola, and have a superficial appearance as if the skin had been raised by having had boiling water spattered over it.

Diagnosis of Variola from Febrile Lichen. — Febrile lichen bears a close resemblance to the papular eruption of variola. The exanthem of febrile lichen appears as small, slightly red papules, ordinarily of the size of millet-seeds. In diagnosticating small-pox from lichen, time is an important factor. The eruption of lichen follows within from twenty-four to forty-eight hours after the initial illness, and never passes through the papular, vesicular, and pustular stages characteristic of variola. In lichen the eruption practically contains no fluid, and even when this is present it is so unlike that of variola that after two or three days from the beginning of the exanthem it would be impossible for a skilful physician to mistake it for small-pox.

Diagnosis of Variola from Syphilis.—Occasionally the practitioner is called upon to diagnosticate variola from pustular syphilitic eruptions. At times this is a very difficult task. In June, 1887, I saw, in consultation with my brother, Dr. W. H. Foster, a negro man affected with a pustular syphilitic eruption which was in all appearances like a severe case of discrete variola on the eighth day of the eruption. The face, trunk, and limbs were thickly studded with pustules, fully four-fifths of which were umbilicated. The man had high fever, (104° F.), pulse 140 per minute, severe pain in lumbar region, nausea, vomiting, sore throat, nasal catarrh, and marked redness of the eyes. The first symptom noticed by the patient was a hard chill. I have for years been familiar with the exanthem of variola, and yet must confess that we arrived at a diagnosis only by exclusion. Inquiry developed the fact that the patient had contracted syphilis four months previously, and that the eruption in question appeared a week or ten days prior to the time I saw him. Examination showed an indurated chancre beneath the prepuce. Upon the syphilitic history and the absence of contact with variola we were enabled to exclude small-pox. This eruption continued upon the man fully three months. In 1885, I saw, with Dr. G. C. Dugas, another very similar case.

It is unnecessary to enter into a discussion of the differential diagnosis of small-pox and scarlatina, typhus fever, meningitis, acute miliary tuberculosis, etc. If the physician awaits the appearance of the characteristic eruption of small-pox he can never confound these diseases with variola. As previously stated, the practitioner is not warranted in proclaiming a positive diagnosis of small-pox until the vesicular stage is reached, unless there is evidence of contact with variola.

PROGNOSIS.—In prognosticating the result of a given case of small-pox the practitioner should be guided by a consideration of the following points:

Age.—The age of the patient materially affects the prognosis. The mortality among infants is frightful, reaching fully 90 per cent. In childhood, up to twelve years of age, the mortality will reach 40 per cent. of unvaccinated cases. Likewise old age is an important factor, the mortality reaching 75 per cent. of all persons beyond sixty years of age.

Sex.—In non-pregnant females the mortality will not exceed that of the male sex. Pregnant females, however, show a vastly greater death-rate, for, superadded to the disease, abortion, miscarriage, or childbirth has great influence upon the results of variola.

Vaccination.—Vaccination is a most important factor in determining the chances of death from variola.

The death-rate in cases of post-vaccinal small-pox varies greatly with the length of time which has intervened between the attacks of vaccinia and variola, and the shorter this period is, the less will be the mortality. Marson claims that the mortality in post-vaccinal small-pox is greatly influenced by the number of insertions of the vaccine virus. From an examination into 4,896 cases of variola, following vaccination, he says the percentage of mortality was as follows

	Per cent.
Having 1 vaccine cicatrix	7.73
" 2 " cicatrices	4.70
" 3 " "	1.95
" 4 or more "	0.55

I do not agree with Marson as to the influence of the number of vaccine cicatrices. In this section vaccinia is introduced by only one puncture, and I have never seen a fatal case of variola in a person who had been vaccinated within ten years prior to the attack of small-pox.

Marson shows by elaborate statistics that the ratio of death risk, where there has been no vaccination, to that after the most defective vaccination, is as three to one; to that after the best vaccination, as seventy to one.

The Type of Small-pox.—There can be no question that the type of variola has great influence in determining the death-rate. Taking a large number of cases the mortality will reach fifty per cent. in the confluent variety, ten per cent. in the semi-confluent type, and seven per cent. in the discrete variety. Marson, from the records of the London Small-pox Hospital from 1836 to 1851, inclusive, reports that among 2,654 cases of confluent, semi-confluent, and discrete varieties of small-pox there were 996 deaths, being a mortality of thirty-seven per cent. Recovery from hæmorrhagic small-pox is rarely witnessed. Death from varioloid is almost unknown at the present day.

Constitutional Condition.—The condition of the constitution of the patient at the time of contracting small-pox has an important bearing upon the prognosis. In persons suffering from consumption, scrofula, syphilis, the hæmorrhagic diathesis, etc., recovery is very exceptional.

Lesions of the Mucous Membranes.—Lesions of the mucous membranes exert a decided influence upon the death-rate. Œdema glottidis, diphtheritic exudations, pneumonia, etc., increase greatly the fatality of the original disease.

TREATMENT.—The treatment of small-pox embraces two important, though widely divergent indications, viz:

1. Palliative treatment, and
2. Prophylaxis.

Palliative Treatment.—There is unquestionably no curative treatment known to medical science for small-pox. The treatment is wholly symptomatic, and must be prescribed with a view of palliating the severity of the symptoms. The idea of a former generation, that medicines could cut short the course of this malady, has very properly been abandoned. Sweating, vomiting, purging, and bleeding the patient, with a view of aborting variola, are not advocated by any reputable physician of the present time. Stiemer has recently, however, asserted that the administration of large doses of quinine during the stage of invasion will modify and shorten the course of small-pox. Quinine when given in large doses will reduce the temperature, but cannot cut short the course of the disease. While we have no medicine which can shorten the course of variola, I nevertheless, from personal experience, subscribe to Marson's claim of the abortive power of vaccination, if performed within three days after the first exposure of the patient to small-pox. Marson says, on this point: "Suppose an unvaccinated person to inhale the germ of variola on Monday; if he be vaccinated as late as the following Wednesday, the vaccination will be in time to prevent small-pox being developed; if it be put off until Thursday, the small-pox will appear, but will be modified; if vaccination be put off until Friday, it will be of no use; it will not have had time to reach the stage of areola, the index of safety, before the illness of small-pox begins; this we have seen over and over again, and know it to be the exact state of the question."

I can add several cases from my own experience which demonstrate the correctness of Marson's statement. I vaccinated two children, aged twelve and fourteen years respectively, three days after exposure to semi-confluent small-pox. In each case the vaccinia pursued a typical course, yet the inital fever of variola appeared and lasted two days. The temperature reached 101° F. and 103° F. in these cases. One patient developed five pustules of variola, the other fourteen pustules. Secondary fever was absent in both cases. Furthermore I have on three occasions vaccinated persons who were sleeping in the same room with small-pox patients, and those so vaccinated failed to take variola. But to thus successfully combat small-pox, vaccine virus must be used which will develop a vaccine vesicle that will reach the areola stage within ten days—the period of incubation in small-pox is fourteen days. The lymph of humanized vaccine virus rarely shows delayed vaccinal results—bovine virus frequently does. Dry lymph from any source has this objection of delay in "taking." The greater certainty of humanized virus to "take" promptly gives it a great advantage over bovine virus. In all cases coming to the physician's attention at the time of exposure it is his solemn duty to put Marson's suggestion into practice.

As soon as a person has contracted small-pox he should, if possible, be placed in a large, well-ventilated room, from which all books, unnecessary clothing, bedding, furniture, and other household articles have been previously removed. The temperature of the room should be kept constantly at 65 or 70 degrees Fahrenheit. The old plan of keeping the patient heavily covered and constantly sweating, and the room dark and unventilated, is a great mistake and should be scrupulously avoided. The covering of the patient should be light, and the bedding and clothing frequently changed. When the chill comes on he should be warmly covered, and sinapisms should be applied to the whole length of the spinal column. During the febrile stage high temperature should be combated with large doses of quinine and digitalis. For an adult forty grains of quinine may be given within four hours, together with twenty-drop doses of tincture of digitalis every eight hours until the temperature is markedly reduced. The antipyretic power of quinine in the exanthemata cannot be denied by any one who has fully tested it. But to produce this effect it must be given in large doses, *i.e.*, ten grains every hour until forty grains shall have been taken. The antipyretic effect of the quinine will be manifested within six hours after its administration, and in twelve hours the maximum reduction of temperature will be reached. The temperature so reduced will generally remain stationary for at least twelve hours.

The temperature can be lowered at least two degrees by this treatment. If the fever again rises to 104° F., the quinine and digitalis should be repeated. Antipyrine has a wonderful effect in reducing temperature. When administered for this purpose it should be prescribed in twenty-grain doses, hourly, for three hours, to an adult. Thus administered it will reduce the temperature for a period varying from twelve to twenty hours. Whenever the fever reaches 104° F., a general warm bath at 100° F. will temporarily reduce it. These baths should be continued for from five to ten minutes, and should be repeated as found necessary. During the febrile stage of variola convulsions frequently occur in children. This fact should be constantly borne in mind by the practitioner, and their occurrence should be forestalled by the administration of hydrate of chloral and bromide of potassium, or paregoric.

After the appearance of the exanthem the treatment must be varied to meet the type of the disease to be combated.

In varioloid, medicines are scarcely ever indicated. The patient should have milk, eggs, and other easily digested articles of food. Confinement to bed is ordinarily unnecessary in this type of variola.

In severe cases of small-pox both local and internal treatment must be prescribed.

Local Treatment.—After trials with various agents as local applications to the exanthem on the surface of the body, I am satisfied that a mixture of carbolic acid and glycerine is the best. A mixture composed of thirty-two grains of crystallized carbolic acid to one pint of glycerine should be brushed three times daily over those portions of the body most thickly studded with pustules. This mixture, owing to the anæsthetic properties of carbolic acid, markedly controls the itching and pain of the eruption, and the glycerine softens the hardened crusts. Various plans of treatment have been advocated for preventing the face from being pock-marked. With some writers the old plan of the Arabs, of opening each pustule, is advised; others recommend the opening and cauterization of each pustule; some advocate painting the surface

with tincture of iodine, with the view of aborting the vesicles by producing coagulation of their contents; others recommend mercurial plasters, solutions of gutta-percha, nitrate of silver, collodion, etc. After various trials I am thoroughly convinced that no local treatment has the power to prevent pitting of the skin. If the papillæ are invaded by the variolous inflammation deep and permanent pock-marks result, no matter what local treatment has been used. If, however, the pustules are superficial the pock-marks will be very slight, even when no local applications have been made. I have repeatedly witnessed very slight pitting follow severe variola where no local treatment had been used. Zülzer says the internal use of xylol will coagulate the contents of the pustules and thereby cut short their development. This claim lacks confirmation. I have never tried it.

The exanthem in the mouth and throat causes pain and difficulty in swallowing. For the relief of these symptoms gargles of warm water, or astringent solutions should be used. This treatment is of course only palliative, for we can no more abort the eruption in the mouth and throat than on the skin. The diet of the patient should be carefully directed by the physician. The disease will tax the strength to the utmost, and therefore nutritious food properly prepared should be freely administered. Milk, eggs, soup, beef tea, gruel, oatmeal, prunes, baked or stewed apples, etc., furnish excellent food for the variolous patient.

Delirium, restlessness, weak and rapid pulse, shrunken features with marked prostration, demand free and fearless use of alcoholic liquors. This treatment offers the patient the only hope of recovery. The amount of alcoholic stimulants to be administered in adynamic states of variola must be decided by the degree of vital depression to be combated.

Constipation should be relieved by mild saline purgatives or enemata. If diarrhœa exists it should be controlled with opium.

If sleeplessness is marked it should be relieved with a mixture of hydrate of chloral and bromide of potassium, or morphine; where copious expectoration or salivation exists, opiates should be given with caution.

Abscesses frequently form in the subcutaneous tissues during the course of variola. The scalp is a favorite location of these abscesses, which when they first appear are small, but continue to enlarge and show but little disposition to point. They should be freely opened when first discovered. When the eruption is copious on the head, or when abscesses form under the scalp, the hair should be cut close to the skin. Numerous boils, terminating in foul ulcers with free discharge of pus, occur in many cases of variola. Boils should be promptly lanced. The depressing effects of suppuration should be combated with full doses of quinine, iron, wine, and concentrated nourishment. As a local application to these abscesses, lint kept wet with black wash is the best.

If erysipelas, pleurisy, pneumonia, etc., complicate an attack of small-pox they should be treated on general principles. Among the most serious complications of small-pox are ophthalmia and ulceration of the cornea. Variolous ophthalmia should be treated by frequently washing the eyes with warm water, and by an astringent collyrium of sulphate of zinc used after each washing. A solution of atropine should be dropped into the eyes as found necessary, when the inflammation is intense. To mitigate the irritation on the eyelids the vesicles should be punctured and the lids frequently covered with cold cream. When the cornea is implicated and perforation is threatened, attempts should be made by local treatment to subdue the inflammation and stop the advance of the ulcer. Atropine should be freely dropped in the eyes, and the lids kept closed with a compress bandage. The eyes should be cleansed several times daily, and a mild solution of sulphate of zinc, two grains to the ounce of water, should be instilled after each cleansing.

Prophylaxis.—Judged by mortuary statistics, the present therapeutic management of small-pox in unvaccinated patients shows but slight improvement over that of one hundred years ago. By judicious symptomatic treatment many cases can be conducted to a favorable termination which would otherwise prove fatal. Prevention is the end to be reached in combating this malady. In the whole field of sanitary science the prevention and control of small-pox are the most certainly attainable, if the efforts of the sanitarian are wisely planned and faithfully executed. In the prevention of the spread of variola the most important of the hygienic considerations to be regarded, are: 1, Isolation; 2, disinfection; 3, vaccination.

Isolation.—No matter how absolute the protection afforded by vaccination there will always be great and insurmountable difficulties in the way of enforcement of this measure among the people generally in this country, where individual ignorance and prejudice are allowed to contravene the public welfare. Therefore, the sanitarian must be prepared to enforce additional measures of prevention and control of small-pox. If a case, or cases, of variola be introduced into a community, the disease cannot spread if the patient be promptly isolated and all infected materials immediately disinfected or destroyed.

Whenever a case of small-pox occurs in a family, the physician's first duty is to isolate the patient and provide nurses and attendants who have been successfully vaccinated or have previously had the disease. If others in the family have not yet been vaccinated they should be vaccinated at once. Those who have previously been vaccinated should be promptly revaccinated. If the small-pox patient be so situated that he can be safely isolated and provided with proper attention, he may be permitted to remain at home for treatment, but the sanitary authorities should furnish a reliable guard to compel isolation and compliance with all necessary sanitary precautions. If isolation at home is impossible, then a properly organized hospital is the only place where such a patient can, with due regard to public safety, be treated. For such purpose a public small-pox hospital is a necessity in every city. It should be located remote from the thickly settled parts of the city, and, if possible, beyond the city limits. This institution should be provided with every necessary comfort, so as to induce patients to cheerfully seek shelter therein. Whenever a case of variola is allowed to remain at home, a large poster should be placed on the door to warn people not to enter or linger there.

In the management of this disease among the poor the greatest possible care and vigilance must be exercised on the part of the municipality. Whenever a case has been found and is to be conveyed to hospital this should be done in a closed ambulance—to use an open conveyance would be criminally negligent. Infected clothing, bedding, etc., may be taken with the patient to the hospital, though it is safer to burn them in the sick-room. When the clothing and household articles of the poor have been destroyed, the public treasury should replace them, for they were destroyed in furtherance of public safety. In burning infected articles and replacing them with new ones, the sanitary authorities will make a most prudent and economical expenditure of money—an expenditure which will be returned to them more than a thousandfold. When infected persons or materials are being taken to hospital, the ambulance should be rapidly driven through the most sparsely inhabited portions of the city contiguous to the hospital, and the police should go ahead and clear the streets until the ambulance has passed. Isolation of small-pox patients is absolutely necessary in preventing the spread of the disease. Without doubt variola can be promptly "stamped out" of a community. But to do this the first cases must be immediately dealt with by isolation, disinfection, and vaccination. To obtain early information of the existence of small-pox the municipality should require physicians and families to promptly report to the sanitary authorities all cases known to them. When a case is found its source must be traced, and thus other cases will be detected. When a case of variola is found the sanitary officer should carefully ascertain the name and residence of every person who has been exposed to it. An officer should be specially charged with the duty of finding every

such exposed person, and should make daily visits to every one of them until the period of incubation is passed. Every person who has been exposed to the disease should be vaccinated, and if formerly vaccinated the operation should be repeated. Every such person refusing to be vaccinated should be quarantined for fourteen days—the period of incubation in variola. Where a person has been exposed to small-pox, and is living in the same house with other families, such family should be quarantined until the period of danger is over. To safely quarantine such persons it may be necessary to confine them in a quarantine station. For this purpose every municipality should maintain a quarantine hospital, near the small-pox hospital, but sufficiently distant to insure safety to its inmates. The sanitary officer should remove persons to the quarantine hospital only when public safety absolutely demands the exercise of this precaution.

Disinfection.—Watson truly says "there is no contagion so strong and sure as that of small-pox." The contagious element exists in the exhalations of the body and in the vesicles, pustules, and scabs. These sources of the disease contaminate the air of the sick-room, and strongly adhere to everything therein. The vitality of the small-pox poison is truly remarkable, if protected from the air, as in instances where infected clothing has been packed away, it can retain its infective power for several years.

The sanitarian has in chemistry, under these surroundings, an indispensable ally. There is no question of our ability to kill every particle of the contagion of small-pox if chemical action is properly adjusted to its task. To do this successfully disinfectants must be brought directly in contact with the contagious matter. Every discharge which passes from the mouth, nose, kidneys or bowels of the patient must be received in suitable receptacles charged with a powerful disinfectant. Every handkerchief, towel, sheet, article of clothing, drinking- or eating-vessel must be purified by heat and disinfectants. If the patient is kept at home, a sheet saturated with a strong solution of carbolic acid should be hung over the door openings outside the sick-room, to prevent the contagious exhalations from passing into other parts of the house.

The sputa and excretions of the kidneys and bowels should be received into vessels containing a sufficient quantity of strong copperas solution, two pounds to the gallon of water. Under no circumstances should excreta be passed into a water-closet or thrown into the privy vault or yard until an additional quantity of copperas water has been added to them. The quantity of the disinfectant should be at least eight times more than that of the excreta.

All eating- or drinking-vessels used in the sick-room should be thoroughly disinfected with a disinfectant solution, and afterward washed in hot water before being carried from the room. Such of the articles as are necessary should be kept and used in the sick-room until the recovery and discharge of the patient.

Every piece of bed- or body-linen from the patient or nurses, or which has been in any part of the sick-room, must be kept in a solution of carbolic acid for two hours and boiled in water for half an hour, before being taken from the patient's room.

Bits of cloth, instead of handkerchiefs, should be used and burned immediately when soiled.

The patient should not be regarded as free from liability to infect others until every scab or scale has been removed. The hair should then be carefully combed so as to remove all particles adhering to the scalp. The whole body should then be washed in a weak disinfectant solution and the patient should hastily go into an adjoining room and dress with clothing undoubtedly free from contagious particles.

Immediately upon the patient leaving the room it should be disinfected and cleaned. To effectually purify the clothing, bedding, etc., hang every article upon lines placed across the room. If there is a carpet on the floor take it up and burn it in the fireplace. Then stop up the fireplace and shut down the windows. Put two pounds of sulphur in an iron pot over a larger vessel holding water, and drop a quantity of live coals into the pot containing the sulphur, and then hastily leave the room and close the door behind you. The room should now be closed for twenty-four hours in order that the disinfectant thus generated may invade every crevice and fully impregnate all materials therein. After twenty-four hours open the windows (closing all others adjacent thereto), and then have the clothing and bedding, which can be washed, put into tubs containing solutions of carbolic acid, chloride of zinc, or copperas, and boiled for one hour in water. These articles should then be taken into a large open space, as far from the thickly inhabited portion of the town as possible, and sunned. There is always danger in the pillows and mattresses, for they cannot be thoroughly fumigated nor can they be washed, therefore these articles should be burned. All stuffed furniture in the room should be taken apart and the upholstering materials burned. Wash all the furniture and the floor with a disinfectant solution. If the walls be papered wash off every particle of such covering and then whitewash the walls. The walls, even when painted, should be washed with a disinfectant solution. After the above precautions are taken, open the windows for free ventilation and leave the room unoccupied for one month.

If the patient should die, the corpse should be thoroughly washed with a strong solution of chloride of zinc or carbolic acid and water, and the body should be wrapped in a sheet fully saturated with one of these disinfectants, and buried at once. Under no circumstances should the body of such a patient be permitted public burial; nor should the corpse be transported from the city by public conveyance—such as cars, boats, etc. Every hearse, hack, or other vehicle in which the body has been conveyed, should be disinfected under the supervision of the sanitary authority immediately after the corpse is removed therefrom.

In waging war against small-pox no alarm or excitement must be felt; it should be met calmly and deliberately. If real skill should direct, and scrupulous conscientiousness execute, the above specified measures of prevention and control, small-pox might simultaneously be introduced into every city in America, and it would be impossible for it to attack any one citizen not already infected.

Vaccination.—In the broad field of natural science no fact is better established than that vaccination, if universally practised, is capable of effectually preventing the appearance of small-pox in man. The history of vaccination, as well as the technique of the operation, will not be discussed in this treatise, inasmuch as the subject, Vaccination, has been assigned to another writer. I must, however, say that, after a large personal experience acquired in making five thousand vaccinations in the public service, I am impressed with the conviction that humanized vaccine virus is decidedly preferable to bovine virus. The facts upon which this opinion is founded are fully presented in a paper, entitled "The Relative Merits of Humanized and Bovine Vaccine Virus," read by me before the Medical Association of the State of Georgia in 1882. This paper may be consulted by referring to the "Transactions of the Medical Association of Georgia, 1882." In view of the prophylactic power of vaccination it should be regarded as an especial and solemn duty upon the part of municipal authorities to annually provide gratuitous vaccination for the indigent poor, and whenever small-pox threatens the community no expenditure of money, within the line of duty compatible with the public good, should be spared by the authorities in order to protect the people under their charge.

The time has not yet arrived, and in democratic America, where the cry of infringment of personal liberty is the shibboleth of the demagogue, the day may never come, when it would be wise to resort to compulsory vaccination. There can be no question but that every unvaccinated person is liable to contract small-pox, and thereby disseminate it among his fellows. This fact constitutes every unvaccinated person a public enemy, and he or she should be dealt with as such. Satisfactory

evidences of successful vaccination should be required of all persons before being allowed to enter public schools, asylums, hospitals, charitable institutions, or municipal, state, or national service. Every immigrant should be required to exhibit like proof before being allowed to land in this country. *Eugene Foster.*

SMELL, THE SENSE OF. The olfactory nerve (so-called) is, like the optic, a prolongation of the cerebrum. Its minute structure is that of the brain-substance, and not of the ordinary cerebro-spinal nerves. It arises by three roots from the posterior part of the anterior lobe of the brain, and forms the olfactory tract which terminates in the bulb, or olfactory ganglion, resting on the cribriform plate of the ethmoid bone. The development of this ganglion is always in proportion to the acuteness of the scent in different animals. It is made up of gray matter, *i.e.*, it is chiefly composed of ganglionic cells.

From it arise about twenty nerve-filaments, which penetrate the cribriform plate and are distributed to the upper third of the anterior nasal chamber. It is the sum total of these fibres which might be more properly called the olfactory nerve. These fibres anastomose freely, they subdivide, and are finally distributed to the "olfactory membrane."

This membrane is considerably thicker than the rest of the nasal mucous membrane. It is only to be found in the upper third of the nasal fossæ, where it extends over the upper, and a portion of the middle, turbinated bones, the septum, and the roof of the fossæ. In animals with acute scent the olfactory region is more extensive than in man. To this membrane exclusively are distributed the terminating branches of the olfactory nerve (see Fig. 2503, on page 212 of Volume V.).

The epithelial covering of this membrane consists of truncated epithelium-cells, and between these, at regular intervals, are to be found peculiarly shaped, slender, nucleated cells ending in rods. These are presumed to be the terminating peripheral apparatus of the olfactory nerve, although their connection with the nerve-filaments has never been satisfactorily demonstrated, owing to the extreme delicacy of the latter. They are analogous to the rods and cones of the retina, and to the hair-cells in the organ of Corti. In the frog they are ciliated. Numerous racemose mucous glands, which keep the membrane in a moist condition, are distributed throughout the olfactory region.

The remaining portion of the nasal chambers is covered by a thin layer of mucous membrane, bearing ciliated columnar epithelium, which is innervated by the fifth nerve. It is provided with simple glands secreting a serous fluid.

That the olfactory region is the one exclusively capable of receiving odorous impressions, and that, consequently, the olfactory is the only nerve endowed with specific olfactive properties, has been proved both by physiological experiments and by pathological anatomy. Dogs in whom the olfactory nerve has been cut refuse meat wrapped up in paper, and are incapable of finding it when hidden. Persons suffering from anosmia due to absence, atrophy, or injury of the olfactory tract or ganglion are deprived of the sense of smell, although they are capable of detecting certain pungent substances, such as bromine, iodine, chloroform, acetic acid, ammonia, etc. There is a difference between the pungent and odorous substances. The former impinge only on the nerve-endings of the fifth nerve, which subserves general sensation; they are not perceived by dogs in whom the nasal branches of that nerve have been divided.

The mechanism of the perception of odorous substances is as little understood as is that of visual and auditory impressions. We know nothing about the nature of odorous substances, and it is impossible to classify them similarly to substances productive of gustation. If we want to describe a certain odor we have to give the name of the substance which produces it.

The act of smelling takes place by the contact of air, laden with odorous particles, with the olfactory portion of the nasal chambers. The diffusion of this air is facilitated by the projecting inferior turbinated bone. By it the ascending air-current is directed against the septum nasi; striking this, it is again deflected, and scattered throughout the recesses of the upper anterior fossæ.

Odorous particles give rise to olfaction only when suspended in gaseous media. Scented water poured into the nose (the patient being in the recumbent position), and kept there by the reflex closure of the nasal fossa by the soft palate, is not smelled, nor does a scented air-current passing from the pharynx through the nares give rise to an odorous impression. Thus, persons having habitually an offensive breath do not perceive it themselves. There is, however, another explanation of this: An odor starting from the air-passages is perceived in the beginning of the trouble, but soon the olfactory nerve becomes accustomed to it, and there is no further perception of it. A patient having cancer of the stomach was greatly annoyed at first by the offensive smell of the material vomited; but soon he became accustomed to the bad odor, and ceased to be aware of it.

Smell is intensified by sniffing. Within certain limits it may be stated that the more quickly the air containing odorous substances passes over the olfactory membrane, the more acute is olfaction. Persons on whom tracheotomy has been performed, and who breathe through a cannula, do not smell at all. Continuous smelling of the same substance, especially when fragrant, gives rise to discomfort and pain in the forehead. At the same time the nerve becomes exhausted, and the sense of smell for that particular substance is temporarily lost. Water, when kept in contact with the olfactory membrane, will also abolish olfaction for a short time. Probably it causes the delicate olfactive rods to swell up, and interferes in this way with their function.

When several odorous substances are mixed, we do not smell a mixture of them, but we perceive them alternately and individually.

Whether an impression can be produced on the olfactory membrane by mechanical or electrical stimulation, corresponding to the visual and auditory sensations excited by the same means, is questionable. It is claimed by some that electrical stimulation of the olfactory region excites a sensation resembling that produced by the emanations from phosphorus.

Subjective odorous sensations are quite frequent, and occur even in the healthy; but most often they are met with in the hysterical and the insane.

In regard to acuteness of smell, man is inferior to most of the higher animals; this is partly due to the neglect of the cultivation of this sense. Hysterical patients are sometimes endowed with a remarkably acute sense of smell; persons who are both blind and deaf, and who are consequently compelled to cultivate and rely on the other senses, have been known to almost equal the dog in the acuteness of smell.

There is an intimate relation between smell and taste, and, in fact, all so-called taste, except that of sweet, sour, bitter, and salt substances, is in reality smell. Delicate flavors that make so many dishes attractive cannot be appreciated when the nose is plugged, or when a person suffers from coryza or anosmia. Thus, vanilla, freshly prepared roast beef, the bouquet of wines, etc., can be relished only by those whose olfactory sense is unimpaired.

That there is an anatomical connection between the organs of smell and taste is evinced by the fact that the odor of sapid substances produces reflexly a flow of saliva.

For perfect olfaction a moist condition of the olfactory membrane is indispensable.

As might be expected, carnivora are possessed of a more acute smell for animal substances than the herbivora, who have a quicker perception of the odor of plants.

L. Bremer.

SNAILS. A popular term applied to those forms of the gasteropod mollusks, belonging chiefly to the order *Pulmonata*, which are provided with a shell. They are divided into the land, fresh-water, and marine species, belonging respectively to the sub-orders *Geophila*, *Lim-*

nophila, and *Thalassophila*. There are some few terrestrial species and a large number of fresh-water and marine forms, belonging to the order *Azygobranchia*, to which the term snail is also sometimes applied. The fresh-water and marine forms are perhaps more commonly known as periwinkles and whelks, while allied genera not provided with a shell are ordinarily spoken of as slugs.

The order *Pulmonata* is characterized by a lingual membrane provided with numerous teeth arranged in many uniform transverse rows; mouth usually supplied with one or more horny jaws, a respiratory organ in the form of a closed chamber lined with pulmonic vessels on the back of the animal and covered by the shell when present—the edge of the mantle being attached—the entrance to the air-chamber being through an opening in the side closed by a valve. The operculum is almost universally absent. The tentacles and eye-peduncles are retractile or contractile. The shell varies in form, and is sometimes rudimentary or wanting. They are hermaphrodites, with reciprocal impregnation, generally oviparous, and all forms, whether terrestrial, fluviatile, or marine, respire free air.

The American species of terrestrial snails live mostly in the forest sheltered under the trunks of fallen trees, layers of decayed leaves, stones, or in the soil itself. They are, as a rule, solitary in their habits; only exceptionally, as sometimes in the early days of spring, do they congregate in considerable numbers in warm and sunny situations, but these assemblies do not last more than a few days; they then scatter and again resume for the rest of the year their solitary mode of living. They are rarely seen abroad except on damp dark days or at twilight, and, indeed, they almost disappear as the forests are cut down, and seem to flee the approach of man.

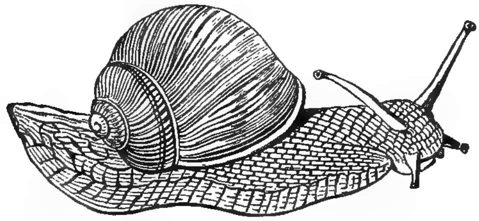

FIG. 3557.—Helix Pomatia Linn.; the European Vineyard Snail, the one most extensively eaten. (From Keferstein.)

The European species, on the other hand, follow in the track of cultivation and are common in gardens and fields, on walls and hedges, and other places exposed to the action of light. It is probably owing to this radical difference in their habits of life that the large majority of our species are so plain and uniformly dull-colored, while the European species are brightly colored. In size the snails vary from those minute species a quarter of an inch or less in length to the gigantic African species belonging to the genera Achatina and Balinus, which sometimes attain the length of eight inches.

The eggs are laid in the early spring. Some few forms are viviparous. As soon as hatched, which takes place in from twenty to thirty days, the young snail devotes himself strictly to the business of eating. He first devours his own shell, and then, according as his instinct leads him, begins on either vegetable or animal food. The majority of them prefer vegetable food, though it is certain that some forms are also fond of animal food, and sometimes prey upon earthworms, their own eggs, or even upon each other. The amount they can eat is enormous, as can well be testified to by the gardener, who often finds a whole field of vegetables almost destroyed in a single night. As might be expected from this, their rate of growth is very rapid, and they frequently double in size within a week. At the first approach of frost they retire into secluded and sheltered spots under logs, stones, or partially burrow into the soil, withdraw into their shells, and dispose themselves for their annual sleep or hibernation, only to be awakened again in from four to six months by the warmth of spring.

They possess the power of secreting a mucus-like material from the general surface of the body at will. The slugs have this function developed to a much greater degree, and it is used by them as a means of defence. Whenever a foreign substance touches them they secrete a quantity of the mucus, which forms a kind of membrane interposed between themselves and the irritating substance. This mucoid material is a non-conductor of heat and impervious for a time to liquids, so that by its means they are enabled for a considerable time to withstand the action of corrosive gases, alcohol, and even boiling water. The fresh-water and marine forms live on the rocks and aquatic plants at the bottoms of ponds and rivers, and along the sea-shore, where they may be seen in immense numbers when at any time, as at ebb-tide, the rocks are exposed.

There are a large number of species of snails which have been used as food. Most of these belong to the genus Helix, of which more than twelve hundred species have been described. Few of the American forms have been so used, partly for the reason that it has never become the custom here, and partly, probably, from the curious fact already mentioned, that the forms indigenous to this country are mostly solitary and do not collect in herds or communities. Many of the European species, on the contrary, herd together in immense numbers and so are very easy to collect and peculiarly adapted to colonization. The "edible snail," *Helix pomatia*, is the one most commonly eaten in Europe, but *H. aspersa* and *H. hortensis* are also very generally used. The first of these has, I believe, never been introduced into this country, but *aspersa* and *hortensis* both have been, and are now found in considerable numbers in certain localities. They retain their habits of congregation, and will no doubt in time be much more generally used as an article of diet than they are at present.

FIG. 3558.—Pomatia Aspersa. (From Binney.)

The ancient Greeks and Romans considered snails as one of their greatest delicacies, and imported them from all parts of the then known world to be reared and fattened in their extensive snail-ponds. In many parts of Africa the large species which are indigenous there are used as a daily food all the year round. At the present time in Austria, France, Switzerland, Spain, and Italy, the collection, rearing, and preparing them for market affords occupation to a large number of people. An idea of the extent of the industry may be gained from the fact that from Ulm alone some 4,000,000 are annually exported, and about 90,000 pounds are sold in the Paris markets every year.

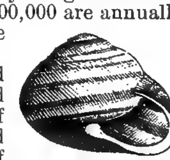

FIG. 3559. — Tachea Hortensis. (From Binney.)

The wild snails are collected and placed in small plots of land cleared of trees and covered with heaps of moss and pine-twigs, and separated from each other by moats, or trails of sawdust, for which snails have a natural antipathy. They are kept here and fed on fresh grass, cabbage-leaves, mint, and other aromatic herbs. In the course of a week or ten days they have become quite obese and, besides, have attained a very delicate flavor; they are then starved for a few days to allow them to get rid of excrementitious matter, when they are ready for the market. To prepare them for the table they are well washed, then broiled, baked, or boiled, shell and all, when they are either extracted and served with various suitable sauces, or are placed on the table entire, to be removed at the time of eating by placing the shell to the mouth and drawing out the animal by sucking it.

The sea-snails are not so extensively used as food, though in England the common periwinkle (*Littorina littorea*) is consumed in immense quantities by the poorer

classes on the coasts as well as in London. About three thousand tons of them, valued at £15,000, are annually shipped to London alone.

There has been a number of cases of poisoning from eating snails which have been allowed to feed on hemlock and belladonna, so that now there has been an inspector appointed in Paris whose business it is to see that they are in fit condition for consumption.

In some persons the ingestion of snails brings on marked attacks of urticaria—the same as is seen in certain cases after eating clams, oysters, and other shell-fish. In these cases it will be understood that there is a more or less marked idiosyncrasy in the person.

An idea of the nutritive value of these mollusks may be gained from the following analysis of the "edible snail," made by Mr. Charles Mene:

Water	72.747
Nitrogeneous matter	17.652
Fatty substances	1.125
Non-nitrogeneous matter	6.300
Salts	2.176
Nitrogen	2.823

In some parts of the world the snail has more or less of a reputation as a "cure" for consumption, concerning which it is only necessary to say that it may be considered as a food of some value as affording a change of diet. *William Barnes.*

SNAKEROOT, BLACK (*Cimicifuga*, U. S. Ph.; *Cimicifugæ Rhizoma*, Br. Ph.; Black Cohosh, etc.); *Cimicifuga racemosa* Elliott; order *Ranunculaceæ* (*Actæa racemosa* Linn.). This is a large, perennial herb, arising from a thick, knotted, horizontal, fleshy rootstock, which gives off numerous cylindrical, branched rootlets from its lower surface, and develops several leafy stems and buds upon the upper. The aërial stems are slender, upright, from one to two and a half metres high, smooth, and cylindrical; they bear two or three ternately compound leaves, the lower very large, twice or thrice primate; the upper ones successively smaller and more simple; leaflets pointed, serrate, ovate, or more or less three-lobed. Inflorescence of one or several long, slender, upright, cylindrical racemes (25 to 50 centimetres long). Flowers very numerous, something over a centimetre across, consisting of four white, concave sepals, which drop as they expand; very numerous, free, slender, spreading stamens, and a single, one-celled, ovoid, pistil, containing several ovules. Petals none, a few of the outer stamens somewhat petaloid.

Black Snakeroot is a common American plant, growing in Canada and in most of the United States. It is collected in various parts of the country, and has been used as a medicine for nearly a century.

The officinal description of the dried rhizome is as follows: "The rhizome is horizontal, hard, two inches (5 centimetres) or more long, about one inch (25 millimetres thick, with numerous, stout, upright, or curved branches, terminated by a cup-shaped scar, and with numerous wiry, brittle, obtusely quadrangular rootlets, about one-twelfth of an inch (2 millimetres) thick; the whole brownish-black, nearly inodorous, and having a bitter, acrid taste. Rhizome and branches have a smooth fracture, with a large pith, surrounded by numerous, sublinear, whitish wood-rays, and a thin, firm bark. The rootlets break with a short fracture, have a thick bark, and contain a ligneous cord branching into about four rays" (U. S. Ph.). Cimicifuga, it is said, should be collected in the autumn; it should be used moderately fresh, as it grows much less active with the lapse of time.

Composition.—Not satisfactorily determined—*starch*, *sugar*, *gum*, *resin*, which were early recognized, are common vegetable derivatives, and found in most plants. Couard obtained a neutral, crystalline, very acrid substance (allied perhaps to *anemonin*). Trimble, working more recently, was unable to get Couard's crystals, but obtained an acrid, amorphous substance. No alkaloid appears to be present, unless Couard's crystalline substance proves to be such, as surmised by Mr. Falck, who has recently (1884) obtained it from the fresh rhizome.

Action and Use.—There is no question that recently dried, or still better, fresh, Cimicifuga is an active substance. Vomiting, diarrhœa, and cardiac depression are caused by large doses; faintness, restlessness, and dizziness, foul breath, and dryness of the pharynx are common results. Smaller doses are said to be tonic, to improve the appetite and digestion, and to strengthen the heart's action. It is reputed to be aphrodisiac and ecbolic, but is not at all reliable in these directions. The most important and acknowledged uses of Cimicifuga are, however, established empirically. It has for many years had a reputation in chorea, and is generally believed to be useful in that obstinate disease. It is also given in chronic rheumatism, and occasionally in pulmonary troubles.

Administration.—The dose is one or two grams of the dried drug; a Fluid Extract (*Extractum Cimicifugæ Fluidum*, U. S. Ph.), and a Tincture (*Tinctura Cimicifugæ*, U. S. Ph.; strength, $\frac{1}{5}$) are available preparations. The precipitated resin, miscalled *cimicifugin*, is in general use by the "Eclectics," and occasionally called for by other physicians. Dose about a decigram.

Allied Plants.—See Aconite.

Allied Drugs.—Colchicum, various alteratives, etc., besides several other *Ranunculaceæ*. *W. P. Bolles.*

SNAKEROOT, VIRGINIA (*Serpentaria*, U. S. Ph.; *Serpentariæ Rhizoma*, Br. Ph.; *Aristoloche Serpentaire ou Serpentaire de Virginie*, Codex Med.). *Aristolochia Serpentaria* Linn., order *Aristolochiaceæ*, is a perennial herb, a foot or so high, from a knotty, horizontal, aromatic rhizome. The stems are slender, flexuose, branching at the base. The leaves of various shapes between ovate and narrow-lanceolate, with heart- or halberd-shaped bases; petiolate entire. Flowers lateral, on slender, straggling, crooked peduncles in the axes of bracts, near the surface of the ground, about an inch long, consisting of a dull purple, single perianth (calyx), whose curved tube has a wasp-like constriction near the middle, and a very oblique, spreading, three-lobed border, of six short stamens connected with the style in three pairs, and a three-celled, many-ovuled, inferior ovary. It is a native of the United States, especially of Pennsylvania, Virginia, and Kentucky, where much of the drug is collected. In the South and West *A. reticulata* Nutt. furnishes a somewhat larger and coarser product. Serpentary is one of the numerous, usually innocent, remedies which have a historical reputation for snake and mad-dog bites. It has been known in medicine for about two hundred years.

The rhizome, as collected for use, is about an inch long, and an eighth or more in diameter, brittle, and tortuous. Section shows excentric wood. Its upper surface has the remains or scars of several stems; its lower is covered with a dense skein of long, slender, fibrous rootlets. All have a dull brown color, an aromatic odor, and a warm, bitter, camphoraceous taste. The rootlets of *Aristolochia reticulata* Nuttall, the Southern or Red River snakeroot, also officinal, are coarser, longer, and less matted together than those above described. Snakeroot is often carelessly collected, leaves and stems may be mixed with it, or Pinkroot, Ladies' Slipper, and other similar-looking rhizomes may be collected with it by accident or for fraud. They are easily distinguished with a little care.

Composition.—Half a per cent. of *essential oil*, about as much *resin*, a little *tannin*, and a *bitter principle* are found in this drug; to the first and last it probably owes its value.

Action and Use.—It is difficult to make this out as anything more than a pleasant, aromatic, bitter tonic. In ounce doses it deranges the digestion, and may cause vomiting, colic, and diarrhœa. Its former employment has been largely as an alterative in various chronic diseases, in rheumatism, and intermittent fever. It is one of the ingredients of the Compound Tincture of Cinchona. Dose, of the powdered drug itself, say two or three grams. Its preparations are: a Fluid Extract (*Ex-*

tractum Serpentariæ Fluidum, U. S. Ph., strength, $\frac{1}{1}$), and a Tincture (*Tinctura Serpentariæ*, U. S. Ph.; strength, $\frac{1}{10}$).

ALLIED PLANTS.—The genus is a large one, of one hundred and eighty, mostly tropical, plants, of both hemispheres. A number of them have aromatic-bitter properties similar to the above, and have been used as medicines. The neighboring genus *Asarum*, represented here by *Asarum canadense* Linn., and in Europe by *A. europæum*, has similar aromatic-bitter properties.

ALLIED DRUGS.—Sweet-Flag, Ladies' Slipper, Cascarilla, Boldo, and many others. *W. P. Bolles.*

FIG. 3560.—Virginia Snakeroot, about one-half natural size. (Baillon.)

SOAP. When natural fats or oils are decomposed by treatment with salifiable bases, they split up into the alcoholic body *glycerin*, on the one hand, and a series of *acids* on the other—principally oleic, palmitic, and stearic acid, in varying proportions, according to the nature of the fat, which acids then unite with the base used in effecting the decomposition of the fat, to form salts—oleates, palmitates, or stearates, or all combined, as the case may be. Such salts are generically called *soaps*, but in common parlance the name soap is applied only to the fatty salts of the alkali bases—potassa, soda, and ammonia, which, in contradistinction to the soaps derived from earthy and metallic bases, are soluble in "soft" water and in alcohol. Of the alkali soaps, furthermore, ammonia soap is used only in the preparation called *liniment of ammonia*, or *volatile liniment* (see AMMONIA), so that the soaps in common use as such are narrowed down to soda and potassa-soaps.

Between soda-soaps and potassa-soaps, as distinct classes, the broad distinction is that soda-soaps tend to be comparatively hard, and potassa-soaps soft, so that the phrase *hard soap* is applied generically to soda-soaps, and *soft soap* to potassa-soaps. But the consistence of soaps is also markedly affected by the nature of the fat used in the manufacture, in the way that fats rich in olein, as is the case with oils, tend to yield softish soaps, whereas those rich in stearin and palmitin, typified by the solid fats, such as tallow, furnish soaps of greater consistence.

Soaps are bodies of a well-known characteristic odor and disagreeable alkaline taste. They dissolve in alcohol and in "soft" water, but in "hard" waters they suffer decomposition by the calcic salts present, and the lime-soap resulting floats in insoluble flocculi on the surface of the water. Soaps are, in general, decomposed by acids, by earthy bases and salts of the earths, and by the heavy metals. The useful property of soaps is that they attack grease, dirt, and dried animal débris, probably by virtue of their free alkalinity, and so affect those substances as to render them soluble in water, and thus readily removable.

The kinds of soap officinal in the U. S. Pharmacopœia for use in technical medicine are as follows: Under the simple title *Sapo*, Soap, is recognized "soap prepared from soda and olive-oil." Such a soap corresponds to what is commercially called *Castile*, or *Spanish*, soap, and is described as "a white or whitish solid, hard, yet easily cut when fresh, having a slight, peculiar odor free from rancidity, a disagreeable, alkaline taste, and an alkaline reaction. Readily soluble in water and in alcohol" (U. S. Ph.). This description applies to the so-called *white* Castile soap, which is a purer and daintier soap than the *marbled* variety, although, containing, as it does, more water, it is not so strong. The marbling of the latter kind of soap is due to streaks of an insoluble iron soap, whose presence constitutes an impurity.

Castile soap is locally detergent, and, by virtue of its free alkalinity, mildly irritant to tender surfaces. Taken internally, it is innocent in moderate quantity, and tends only to relax the bowels and neutralize acid in the primæ viæ. Locally, free ablutions of soap and water are beneficial in certain forms of skin-disease, such as acne, and, as regards internal giving, the principal application of soap is as a ready and innocent alkali to administer in cases of poisoning by any of the strong acids. A strong aqueous solution—one part of soap to four or five of water—should in such cases be very freely administered pending the arrival of more powerful and appropriate alkaline antidotes. Soap and water is also much used as a cathartic enema, but in sensitive conditions of the rectum may irritate. Pharmaceutically, soap is much used as an excipient in pill-composition, but due regard must be paid to its chemical susceptibilities, as above detailed. From Castile soap are made the following officinal preparations: *Emplastrum Saponis*, Soap Plaster, is compounded of soap, one part, and lead-plaster, nine parts, mutually

incorporated when in the fluid condition, and the product evaporated to the proper consistence. Soap-plaster is a feebly active plaster, devoid of specific medicinal properties. *Linimentum Saponis*, Soap Liniment, contains, in one hundred parts, ten of soap, five of camphor, one of oil of rosemary, seventy of alcohol, and the rest water. This preparation makes an excellent gently stimulant embrocation, and takes the place of the *camphorated soap liniment*, or so-called *opodeldoc* of older revisions of the Pharmacopœia, an article substantially the same in composition as the present, but prepared from the common white soap made of animal fat, instead of from Castile soap.

The second variety of soap officinal is entitled *Sapo Viridis*, Green Soap, and is defined to be "soap prepared from potassa and fixed oils." The definition is a broad one, including all potassa ("soft") soaps, but the varieties suitable for medical use are those made from vegetable oils, in contradistinction to those prepared from animal fats. Green soap is thus described: "A soft, greenish-yellow, unctuous jelly, having a peculiar odor, which should be free from rancidity, and an alkaline reaction. Soluble in water and in alcohol, without leaving more than a small residue of insoluble matter" (U. S. Ph.). The green soap in common medicinal use is of German importation, as is also its medicinal reputation. This form of soap is more strongly alkaline, and therefore more detergent, on the one hand, and more irritating to sensitive tissues on the other, than the hard soda-soaps. Severe pain is easily excited upon tender surfaces, such as that of an eczematous patch of skin, by applications of green soap. The medicinal use of the soap is as a detergent and "alterative" application in certain forms of skin-disease, notably in *eczema rubrum*. The part is commonly washed with the green soap, and afterward dressed with some bland substance, such as ointment of oxide of zinc.

From green soap is prepared an officinal *Tinctura Saponis Viridis*, Tincture of Green Soap, which is an alcoholic solution of green soap, sixty-five per cent., and oil of lavender, two per cent. The preparation is used as a local application to the skin, instead of an extemporaneous solution of the soap. *Edward Curtis.*

SOAP BARK (*Quillaia*, U. S. Ph.; *Panama, Bois de*, Codex Med.), the bark of *Quillaya Saponaria* Molini, order *Rosaceæ*, is a good-sized, evergreen tree, with alternate stipulate, ovate, leathery leaves, polygamous; regular flowers arranged in small cymes, and a stellate fruit of five diverging carpels. The perfect flowers have a five-lobed, valvate calyx; five imbricated, narrow, spatulate petals, a conspicuous five-lobed glandular disc; between the lobes of this disc are five stamens opposite the petals, and arising from the lobes five more opposite the sepals. Ovary five-celled, many-ovuled. Seeds flattened, conspicuously winged. The central flower of each cyme is perfect, the lateral are usually staminate. This species is a native of Central America and of the tropical parts of South America, Peru, Brazil, Chili, etc. It is of common occurrence, and its bark has been known to be useful in washing for a long time.

Soap Bark is imported in considerable quantities, for various purposes connected with manufacture—sizing, cleansing, etc.—and has of late found a not very commendable place in syrups for aerated waters, and in beers, to make them hold their froth. It is a recent addition to the officinal list, and is described as follows: "Flat, large pieces, about one-fifth of an inch (5 millimetres) thick; outer surface brownish-white, often with small patches of brown cork attached, otherwise smooth; inner surface whitish, smooth; fracture splintery, checkered with pale brownish bast-fibres, embedded in white tissue; inodorous, very acrid and sternutatory."

This bark contains, as its only valuable derivative, *Saponin* (*Quillain*) to the extent of eight per cent.—a white, amorphous, neutral powder, of, at first, a sweetish, afterward sharp, burning taste. It is odorless, but provokes violent sneezing. Water dissolves it readily, and even with so little as one-tenth of one per cent. holds its bubbles like soap-suds. Strong alcohol dissolves it but little, ether almost none. Saponin is a glucoside, and yields *Sapogenin* upon treatment with diluted acids. It is also claimed by recent analysts that it is not a pure compound, but a mixture of *quillaic acid, sapotoxin*, and others, of

FIG. 3561.—Soap-bark Tree. (Baillon).

which the two named are active muscle-poisons, especially if administered subcutaneously.

USES.—Soap Bark, or an infusion or tincture made from it, is useful as a detergent in washing fine linens, laces, etc., cleaning the surface of paintings and other fine work of that kind. It is also an ingredient of some cosmetic preparations—lotions, hair-washes, etc. Its use in syrups has been referred to; it has been further employed to a small extent as an emulsifying agent. Physiologically it is a pretty active substance, paralyzing voluntary muscles with considerable rapidity, and producing local anæsthesia. It is also a local irritant. These properties have not, however, been put to therapeutic use. As an expectorant, in small doses, it has been recommended, also as an alterative in place of sarsaparilla, but its value is at least doubtful.

ALLIED PLANTS.—See ROSES.

ALLIED DRUGS.—SOAPWORT (see next article). *Saponaria officinalis* Linn., and numerous other plants of the Pink family contain saponin in their roots. So do the Polygalas (see SENEGA). It is also found in individual species of several other orders. There is some doubt as to the exact identity of the saponin of these different plants, as the different names given to it will show—*Struthiin, Polygalin, Githagin, Monninin*, etc.

See also SARSAPARILLA. *W. P. Bolles.*

SOAPWORT (*Saponaire officinale*, Codex Med.; "Bouncing Bet"), *Saponaria officinalis* Linn., order *Caryophyllaceæ*, is a very well-known European perennial herb, freely naturalized here, and often a troublesome weed around the edges of gardens and in rich waste places. It is about two feet high, with ovate, opposite, usually sessile, three- or five-nerved leaves, and cymes of large white, or pink-colored, pink-like flowers clustered at the top of the stem. All parts of the plant, but especially the roots, contain the neutral, amorphous, white, acrid, sternutatory substance *saponin*, described in the preceding article. Soapwort may be used, like Quillaia, to make

a viscous suds-like solution for washing or sizing. It is also said to be employed in the preparation of mucilaginous expectorant teas (*tisanes*).

ALLIED PLANTS.—The order to which *Saponaria* belongs contains a large number of rather bland, mucilaginous, or at least saponin-containing plants, few of which have any medicinal value, but many of them are favorite and beautiful flowers, *e.g.*, Pinks, of many kinds. *Agrostemma* and *Gypsophila* are genera notable for the amount of saponin they contain.

ALLIED DRUGS.—Quillaia, Sarsaparilla, Senega.

W. P. Bolles.

SODEN, Province of Hesse-Nassau, Prussia. This watering-place, lying in the valley of the Taunus, at an elevation of four hundred and sixty feet above tide-water, is well protected on the north from cold winds, and enjoys, in consequence, a very mild climate. In midsummer, indeed, it is sometimes too hot for comfort, and the pleasantest times of the year for a stay at Soden are the spring and fall.

The mineral springs are twenty-four in number, and differ considerably in the proportion of mineral ingredients and in the temperature of their waters. The waters are saline, and contain also varying proportions of alkaline and ferrous carbonates. The proportion of sodium chloride runs all the way from 2.4 to 14.6 parts per thousand, and that of ferrous carbonate from 0.009 to 0.04 part in a thousand. The temperature of the different springs varies between 59° and 86° F.

The diseases for the relief of which Soden is visited are chiefly chronic affections of the respiratory organs. Advanced pulmonary phthisis is, however, seldom benefited by a stay at this resort. Chronic catarrhal affections of the digestive tract, and anæmia and debility occurring during convalescence from acute diseases, also furnish indications for a course of treatment at Soden. The therapeutic methods employed are similar to those in use in other German spas. The season extends from May to November. *T. L. S.*

SODIUM. I. GENERAL MEDICINAL PROPERTIES OF THE COMPOUNDS OF SODIUM.—From the close chemical alliance between sodium and potassium, theory would assign to compounds of sodium physiological properties similar in kind to the corresponding potassic compounds, but less strongly pronounced. The prediction is true in that the sodic effects, such as they are, are potassic effects weakened; but an inference that all the potassic effects, in kind, will be reproduced to some degree in the action of sodium, will not hold. Referring to the article Potassium, the notable effects of that metal are irritation, catharsis, cardiac paresis, general motor paresis, oxidation quickening, and, toxicologically, general toxæmia. Sodium, in comparison, is irritant, salt for salt, in decidedly less degree; is purgative in only slightly less degree; paralyzes heart and motor function so very little that the action only appears at all in excessive dosage in animal experimentation; scarcely seems to quicken oxidation at all, nor, even in fullest dosage, to impoverish the blood after the manner of potassium. So far, however, as concerns those compounds of sodium that are alkaline in reaction, or which, as in the case of citrates, acetates, and tartrates, are converted into an alkaline compound in the blood, the degree of alkalinity is but little less than that of the analogous potassic compounds, and hence the effects that follow, simply from the fact of such alkalinity, are, with sodic compounds, well pronounced. But yet, therapeutically, so far as constitutional alkalizing is concerned, the diseases calling for alkaline medication are also specifically benefited by the specific potassium effects, so that in their case sodic salts, though efficiently alkaline enough, still cannot compete in curative power with their potassic rivals.

II. THE MEDICINALLY USED COMPOUNDS OF SODIUM.—As in the case of potassium, those compounds only will be here discussed whose effects are either *sui generis* to the compound, or are determined mainly by the basic radicle. Such salts, officinal in the U. S. Pharmacopœia, are the following: *Hydroxide* (hydrate), *carbonates*, normal and acid, (pyro-) *borate*, *acetate*, *potassio-sodic tartrate*, *sulphate*, *phosphate*, *pyrophosphate*, *nitrate*, and *chlorate*. Of these the potassio-sodic tartrate (Rochelle salt) will be found discussed under the title POTASSIUM. Other sodic salts, whose properties are mainly derived from the acid radicle of the composition, are treated of under the title of such radicle. Such pharmacopœial salts are the following: *Arseniate*, see ARSENIC; *benzoate*, see BENZOIC ACID; *bromide*, see BROMIDES; *chloride*, see CHLORIDES; *hypophosphite*, see HYPOPHOSPHITES; *hyposulphite*, see SULPHITES; *iodide*, see IODIDES; *salicylate*, see SALICYLIC ACID; *santoninate*, see WORMSEED; *silicate*, see SILICATES; sulphite, see SULPHITES; sulpho-carbolates, see SULPHO-CARBOLATES.

Sodic Hydroxide (Hydrate): NaOH.—This substance, commonly called *Caustic Soda*, is officinal in the U. S. Pharmacopœia, in solid condition, under the title *Soda*, Soda, and in about five per cent. aqueous solution, as *Liquor Sodæ*, Solution of Soda. Soda is "a white, hard, opaque solid, generally in form of fibrous pieces, or of white cylindrical pencils, deliquescent in moist air, but in dry air becoming dry and effiorescent, odorless, having an intensely acrid and caustic taste, and a strongly alkaline reaction. Soluble in 1.7 part of water at 15° C. (59° F.), and in 0.8 part of boiling water; very soluble in alcohol. When heated nearly to a red heat, it melts, forming an oily liquid. At a strong red heat, it is slowly volatilized unchanged. Its aqueous solution dropped into solution of tartaric acid, so that the latter remains in excess, produces neither a precipitate nor cloudiness" (U. S. Ph.). Soda "should be kept in well-stopped bottles made of hard glass." Soda is commonly made by evaporating an aqueous solution of the substance, until the water is driven off and the hydroxide remains in a state of fusion, and then either pouring the viscid fluid into cylindrical moulds or allowing it to harden *en masse*. Solution of soda may be made by dissolving soda in water, but is commonly prepared from the carbonate by decomposition with lime in the presence of water. Calcic carbonate precipitates, and the solution of soda, clarified by straining and settling, is separated by siphonage. Solution of soda is "a clear, colorless liquid, odorless, having a very acrid and caustic taste, and a strongly alkaline reaction. Specific gravity about 1.059" (U. S. Ph.).

Soda and its solution are powerfully alkaline and caustic, like potassa, but to a somewhat inferior degree. Soda is available as a caustic, to be used after the manner of potassa, but potassa being the stronger agent, is generally preferred. Solution of soda is possible as a local alkali for the skin or the stomach, but the carbonates are almost always used in preference. If given internally, the dose of solution of soda would range from 1.00 to 4.00 Gm. (fifteen to sixty minims), largely diluted. In considerable quantity, undiluted, solution of soda would prove a caustic poison, with symptoms generally similar to those of poisoning by potassa.

Normal Sodic Carbonate: $Na_2CO_3.10H_2O$.—Sodic carbonate in crystals or effloresced powder is officinal in the U. S. Pharmacopœia as *Sodii Carbonas*, Carbonate of Sodium; and the effloresced powder, baked "at a temperature of about 45° C. (113° F.)" until it has lost one-half its weight by the driving off of its water of crystallization, is also officinal under the title of *Sodii Carbonas Exsiccatus*, Dried Carbonate of Sodium. Sodic carbonate is the salt commonly called *sal soda* or *washing soda*, and is obtained in part from natural deposits—"native soda," so called—in part from the ashes of certain plants growing in or near the sea, the impure yield of which constitutes *barilla* or *kelp*, and in part by artificial making from sodic chloride, sodic sulphate, or the mineral *cryolite*. Sodic carbonate occurs as "large, colorless, monoclinic crystals, rapidly efflorescing in dry air, and falling into a white powder, odorless, having a sharp, alkaline taste, and an alkaline reaction. Soluble in 1.6 parts of water at 15° C. (59° F.), in 0.09 part at 38° C. (100.4° F.), and in 0.25 part of boiling water; insoluble in alcohol. When heated to about 35° C. (95° F.), the

salt melts; on further heating, all the water (62.9 per cent.) gradually escapes, and, at a red heat, the anhydrous residue fuses. A fragment of the salt imparts an intense yellow color to a non-luminous flame. The aqueous solution strongly effervesces on the addition of an acid" (U. S. Ph.). The dried salt of the Pharmacopœia, a fused mass as first prepared, finally presents itself as a white powder. Both forms of the carbonate should be kept in well-stopped bottles.

Sodic carbonate combines, very purely, strong alkalinity with absence of specific qualities of any kind except the irritation or even causticity in concentrated application which is inherent in a powerful soluble alkali. Its uses are solely those of a local alkali, and are practically confined to external employment in lotion or ointment in skin-affections. Lotions average two per cent. in strength, and ointments between two and ten, the basis being lard. For internal use, the acid carbonate, next to be described, is preferred, because of its more agreeable flavor and milder action. In considerable quantity and strong solution the normal carbonate is a corrosive poison.

Acid Sodic Carbonate: $NaHCO_3$.—This salt, the well-known *cooking-soda*, so called, is officinal in the U. S. Pharmacopœia in two grades of purity. One, corresponding to ninety-five per cent. of the pure salt, is entitled *Sodii Bicarbonas Venalis*, Commercial Bicarbonate of Sodium; and the other, made from this commercial variety by a process of purification, and corresponding to ninety-nine per cent. of pure salt, is called by the unqualified title *Sodii Bicarbonas*, Bicarbonate of Sodium. This carbonate is derived primarily from the normal salt by artificially forcing upon the latter carbon dioxide gas. Bicarbonate of sodium occurs as "a white, opaque powder, permanent in the air, odorless, having a cooling, mildly saline taste, and a slightly alkaline reaction. Soluble in twelve parts of water at 15° C. (59° F.), and insoluble in alcohol. It is decomposed by hot water. When heated to about 70° C. (158° F.), the salt begins to lose moisture and carbonic acid gas, and, on continued heating, loses about thirty-seven per cent. in weight. At a red heat the anhydrous residue melts; and a fragment of the salt imparts an intense yellow color to a non-luminous flame. The aqueous solution, on being heated disengages carbonic acid, and finally contains carbonate of sodium" (U. S. Ph.).

The bicarbonate of sodium, is purely alkaline, like the normal salt, but to a less degree, and by reason of that fact is far less irritant. In all ordinary dosage it is indeed practically free from danger. Its taste also is mildly mawkish only, instead of harshly alkaline. For these various reasons this salt is a favorite one for stomachic alkalizing, as in acid dyspepsia or diarrhœa. It is also much used to make alkaline lotions for the skin. Internally from 1.00 to 4.00 Gm. (fifteen to sixty grains), may be given at a dose in water, and externally washes or ointments may be made in the same manner and of the same strengths, as in the case of the normal carbonate. Both of the carbonates are incompatible with acids and acidulous salts, lime-water, ammonic chloride, and salts of the metals, and metals of the earths.

Troches of the bicarbonate—*Trochisci Sodii Bicarbonatis*—are officinal in the U. S. Pharmacopœia, each troche containing 0.20 Gm. (three grains) of the salt. The salt is also an ingredient of the pharmacopœial preparations, *Mistura Rhei et Sodæ*, for which see Rhubarb, and *Pulvis Effervescens Compositus*, for which see *Potassio-Sodic Tartrate*, under Potassium.

Sodic (Pyro-) Borate: $Na_2B_4O_7, 10H_2O$.—This salt—the familiar substance *borax*—is officinal in the U. S. Pharmacopœia as *Sodii Boras*, Borate of Sodium. It occurs as "colorless, transparent, shining, monoclinic prisms, slightly efflorescent in dry air, odorless, having a mild, cooling, sweetish, afterward somewhat alkaline taste, and an alkaline reaction. Soluble in 16 parts of water at 15° C. (59° F.), and in 0.5 part of boiling water; insoluble in alcohol. At 80° C. (176° F.) it is soluble in one part of glycerin. When heated, the powdered salt begins to lose water, then melts; on further heating, swells up and forms a white porous mass, which, at a red heat, fuses to a colorless glass, with complete loss of water of crystallization (47.1 per cent.). A fragment of the salt imparts an intense yellow color to a non-luminous flame. The saturated aqueous solution, on the addition of sulphuric acid, deposits shining crystalline scales, which impart a green color to the flame of alcohol" (U. S. Ph.). Borax occurs native in Persia and adjacent neighborhoods as a saline efflorescence of the borders of lakes, and in California as a crystalline deposit at the bottom of a small lake. It is also made from other native borates.

Borax is locally bland and constitutionally innocent, and its medicinal virtues seem to reside in the combination of feeble alkalinity with a fair degree of antiseptic power derived from its acid radicle. Borax works well as a mild detergent alkali in skin-diseases or catarrhs, and ulcerations of mucous membranes, particularly of the mouth. A lump held in the mouth and slowly sucked seems to excite the secretions of pharynx and larynx, and in case of huskiness from dry catarrh of these parts temporarily restores something of the natural quality to the voice—an important matter to a singer or speaker affected with a cold. Internally, borax may be used as a feeble alkali, and it has been accredited also with a power to promote menstruation, correct dysmenorrhœa, and excite uterine contractions—a power which until better substantiated than at present, it is wisest not to trust to in an emergency. Borax may be given internally in doses of from 1.00 to 3.00 Gm. (fifteen to forty-five grains), and, externally, may be applied in lotions ranging from one to six per cent. in strength (limit of solubility in water), or in ointment of thirty per cent. strength. Borax has been experimented with, among a host of other substances, for the purposes of "antiseptic surgery," and has been experimentally found to prevent the development of microzymes in aqueous solution of from one-half to one per cent. strength.[1]

Sodic Acetate: $NaC_2H_3O_2.3H_2O$.—The salt is officinal in the U. S. Pharmacopœia as *Sodii Acetas*, Acetate of Sodium. It occurs as "large, colorless, transparent, monoclinic prisms, efflorescent in dry air, odorless, having a saline, bitter taste, and a neutral or faintly alkaline reaction. Soluble in 3 parts of water, and in 30 parts of alcohol at 15° C. (59° F.); in 1 part of boiling water, and in 2 parts of boiling alcohol. When heated, the salt melts, and on further heating loses all its water (39.7 per cent.), and falls into a white powder. At a higher temperature this powder again melts, and, at a red heat, it is decomposed, with the evolution of empyreumatic, inflammable vapors, leaving a blackened residue of an alkaline reaction, which imparts to a non-luminous flame an intense yellow color, not appearing more than transiently red when observed through a blue glass. On adding sulphuric acid to a concentrated solution of the salt, and heating, vapor of acetic acid is evolved. A solution of the salt is rendered deep red by ferric chloride, and, on boiling, a red precipitate is formed" (U. S. Ph.). Sodic acetate hardly merits the foregoing detailed description, since it is very rarely used in medicine. Its purpose would be as a constitutional sodic alkali, its acid, as in the case of other alkaline acetates, undergoing conversion, in the blood, to carbonic. It may be administered in doses of from 2.00 to 4.00 Gm. (thirty to sixty grains).

Potassio-sodic Tartrate. (See under POTASSIUM.)

Normal Sodic Sulphate: $Na_2SO_4.10H_2O$.—This salt, commonly called *Glauber's Salt*, is officinal in the U. S. Pharmacopœia as *Sodii Sulphas*, Sulphate of Sodium. It occurs in "large, colorless, transparent, monoclinic prisms, rapidly efflorescing on exposure to air, and ultimately falling into a white powder, odorless, having a cooling, saline, and somewhat bitter taste, and a neutral reaction. Soluble in 2.8 parts of water at 15° C. (59° F.), in 0.25 part of water at 33° C. (91.4° F.), and in 0.4 part of boiling water; insoluble in alcohol. When heated to about 30° C. (86° F.), the salt melts, and, on further heating, gradually loses all its water (55.9 per cent.). At a red heat the anhydrous salt melts without decomposition. A fragment of the salt imparts to a non-luminous flame an intense yellow color, not appearing more than tran-

siently red when observed through a blue glass. The aqueous solution yields, with test-solution of chloride of barium, a white precipitate, insoluble in nitric acid" (U. S. Ph.). The salt should be kept in well-stopped bottles. Sodic sulphate is formed as a by-product in the manufacture of many chemicals. It is a salt of low diffusion-power, and hence in full dose, in comparatively strong solution, is a purgative. As such it is, like the other alkaline sulphates, powerful in action, producing watery stools, with nausea and griping. From its sickening taste it has been almost wholly superseded by the less disagreeable magnesic sulphate (Epsom salt). From 15.00 to 30.00 Gm. (half to one ounce) is a full purgative dose, to be taken in aqueous solution, aromatized or slightly acidified to disguise the nauseous bitter taste of the salt. Sodic sulphate is a purgative ingredient of many mineral waters.

(Di-) Sodic (Ortho-) Phosphate: $Na_2HPO_4.12H_2O$.—This salt, the common tribasic phosphate, so called, or *tasteless purging salt*, is officinal in the U. S. Pharmacopœia as *Sodii Phosphas*, Phosphate of Sodium. It occurs in "large, colorless, transparent, monoclinic prisms, speedily efflorescing and becoming opaque on exposure to air, odorless, having a cooling, saline, and feebly alkaline taste, and a slightly alkaline reaction. Soluble in six parts of water at 15° C. (59° F.), and in two parts of boiling water; insoluble in alcohol. When heated to about 40° C. (104° F.) the salt melts, yielding a clear liquid, and, on continued heating to near 100° C. (212° F.), it loses all its water of crystallization (60.3 per cent.). A fragment of the salt imparts to a non-luminous flame an intense yellow color, not appearing more than transiently red when observed through a blue glass" (U. S. Ph.). Sodic phosphate is made from the calcic phosphate of calcined bone, by decomposition by sulphuric acid. It should be kept in well-stopped bottles in a cool place.

Sodic phosphate is a bland salt, of low diffusion-power, whose prominent physiological properties are to purge mildly, and, as animal experimentation has shown,[2] to quite notably excite the secretion of bile. At the same time it is feebly alkaline, and possessed of a clean, non-nauseous, salty taste, quite like that of common salt. Therapeutically this phosphate may be used for the general purposes of the milder saline purges, and, more specially, has also proved of avail, even in non-purgative doses, to correct bowel-derangements associated with acidity and assumed sluggishness of the liver. From its mildness and not unpleasant taste it is particularly convenient for giving to young children. Mixed with foods, such as soup, in lieu of common salt, it may be administered in moderate quantity without suspicion. As a purge the dose for an adult is about 30.00 Gm. (one ounce); but for corrective purposes, much less—even so little as 0.65 Gm. (ten grains)—given a number of times through the day, may suffice.

Normal Sodic Pyrophosphate: $Na_4P_2O_7.10H_2O$.—The salt is officinal in the U. S. Pharmacopœia as *Sodii Pyrophosphas*, Pyrophosphate of Sodium. It is not used in medicine, and is officinal for pharmaceutical purposes only to prepare ferric pyrophosphate.

Sodic Nitrate: $NaNO_3$.—The salt is officinal in the U. S. Pharmacopœia as *Sodii Nitras*, Nitrate of Sodium. It occurs in "colorless, transparent, rhombohedral crystals, slightly deliquescent in damp air, odorless, having a cooling, saline, and slightly bitter taste, and a neutral reaction. Soluble in 1.3 part of water at 15° C. (59° F.), and in 0.6 part of boiling water; scarcely soluble in cold, but soluble in 40 parts of boiling alcohol. When heated to about 312° C. (594° F.), the salt melts, and on further heating it is decomposed, giving off oxygen and leaving a residue which emits nitrous vapors on the addition of sulphuric acid. Thrown upon red-hot coals the salt deflagrates. A fragment of the salt imparts to a non-luminous flame an intense yellow color, not appearing more than transiently red when observed through a blue glass" (U. S. Ph.). The salt should be kept in well-stopped bottles. Sodic nitrate is the salt called *cubic nitre*, and is obtained from South America, where it occurs native. It is a salt of high diffusion-power, and in its physiological relations closely resembles ordinary nitre (potassic nitrate), except that it is, of course, devoid of the characteristic properties of a potassic salt as such. Its use in medicine has so far been an empirical employment in dysentery, in which disease 30.00 Gm. (one ounce) of the salt has been given divided in frequent doses throughout the day, in dilute aqueous solution. It is not a standard medicine.

Sodic Chlorate: $NaClO_3$.—The salt is officinal in the U. S. Pharmacopœia as *Sodii Chloras*, Chlorate of Sodium. It occurs in "colorless, transparent, tetrahedrons of the regular system, permanent in dry air, odorless, having a cooling, saline taste, and a neutral reaction. Soluble in 1.1 parts of water, and in 40 parts of alcohol at 15° C. (59° F.); in 0.5 part of boiling water, and in 43 parts of boiling alcohol. When heated, the salt melts and afterward gives off a portion of its oxygen, finally leaving a residue of a neutral reaction completely soluble in water. A fragment of this residue imparts to a non-luminous flame an intense yellow color, not appearing more than transiently red when observed through a blue glass" (U. S. Ph.). The salt "should be kept in well-stopped bottles, and should not be triturated with readily oxidizable or combustible substances." Sodic chlorate has the peculiar medicinal properties of the potassic salt of the same acid, except in regard to the effects of potassium compounds as such. It is important only because of its excess of solubility as compared with potassic chlorate. The medicinal uses are the same as those of the latter-named salt, which see under Potassium.

Edward Curtis.

[1] Sternberg: Am. Journal of the Med. Sciences, April, 1883, p. 334.
[2] Rutherford: The Practitioner, vol. xxiii., p. 414.

SOILS IN THEIR RELATION TO HEALTH. It would be impossible to thoroughly understand and predict the effect of soils on health, under the constantly varying conditions of civilized life, without a knowledge of their origin, composition, and characteristics.

DEFINITION OF SOIL.—Soils may be defined as débris resulting from the action of natural forces on the rocks covering the surface of the earth. This disintegration is constantly going on; mountains are being broken down by the action of frost and heat; the disrupted pieces are being carried down the slopes and broken into finer pieces by the streams and torrents; and the finer particles are being carried still farther by the rivers, till they are deposited either along the banks in alluvial flats, or in deltas. In the early history of this planet the ocean was the great destroyer, beating against the rocks that had been elevated by the shrinking of the earth's crust; breaking them down and grinding them into fine particles and finally carrying away the lighter portions and depositing them in quiet bays and lagoons. It might be supposed that soils would resemble the underlying rocks, *i.e.*, sandy soils superimposed on sandstone, marls on limestone, and the like. This, however, is not always the case; soils of different kinds being scattered seemingly at random over the face of the globe.

STRUCTURE OF SOILS.—"Soil, examined mechanically, is found to consist entirely of particles of all shapes and sizes, from stones and pebbles down to the finest powder, and on account of their extreme irregularity of shape, they cannot lie so close to one another as to prevent there being passages between them, owing to which circumstance soil in the mass is more or less *porous*." Even the smallest particles are "not always solid, but are much more frequently porous, like soil in the mass." "A considerable portion of this finely divided part of the soil, *the impalpable matter* as it is generally called, is found, by the aid of the microscope, to consist of broken-down vegetable tissue; so that when a small portion of the finest dust from a garden or field is placed under the microscope, we have exhibited to us particles of every variety of shape and structure" ("Minutes of Information on Drainage"). The spaces that exist between these particles, or the "pores" of the soil, may be divided into two classes: "First, the large ones which exist between the particles; and, second, the very minute ones which

occur in the particles themselves." "The larger pores—those between the particles of soil—communicate most freely with each other, so that they form canals; the small pores, however freely they may communicate with one another in the interior of the particle in which they occur, have no distinct connection with the pores of the surrounding particles."

COMPOSITION OF SOILS.—The particles described above may be divided into two great classes: Organic and inorganic. "The organic part of soils, called 'humus' by some writers, is derived chiefly from the remains of vegetables and animals which have lived and died in or upon the soil; which have been spread over it by rains; or which have been added by the hands of man for the purpose of increasing its natural fertility" ("Elements of Agricultural Chemistry and Geology," J. F. W. Johnson). The proportion of this organic matter varies in different soils; as, for instance, in peaty soils it forms fifty to seventy per cent. of the whole weight, while in ordinary good soil it does not rise much above eight per cent. Humus furnishes carbonic acid, ammonia, and some other compounds.

The *inorganic* part of soils may be divided into those substances which are soluble and those which are not soluble in water. The soluble portion consists mainly of common salt, gypsum, sulphate of soda, and sulphate of magnesia, with traces of the chlorides of calcium, magnesium, and potassium, and of soda, potash, lime, and magnesia in combination with nitric and phosphoric, and with humic and other organic acids. This soluble portion is so great in some countries as to form a white incrustation on the surface of the ground in hot seasons. The insoluble portion of soils rarely forms less than ninety-five per cent. by weight, and consists mainly of silica, alumina (usually thirty to thirty-five per cent.) and lime, in the form of sand, clay, and lime.

CLASSIFICATION OF SOILS.—Soils are classified according to the proportion of these three constituents (sand, clay, and lime), as they are "all either sandstones, limestones, or clays of different degrees of hardness, or a mixture in different proportions of two or more of them." A *sandy soil* is any dry soil not unusually rich in vegetable matter, and containing not more than ten per cent. of clay. A *sandy loam* is similar to the above, but contains from ten to forty per cent. of clay. A *loamy* soil contains seventy to eighty-five per cent. of clay; a *clay loam* seventy to eighty-five per cent. A proportion of from eighty-five to ninety-five per cent. of clay makes a *strong clay* soil, and where no sand is present we have a pure *agricultural clay*. Soil containing more than five per cent. of carbonate of lime is called a *marl;* more than twenty per cent., a *calcareous soil.*

PHYSICAL CHARACTERISTICS.—The density of different soils varies greatly, as, for example, dry peaty soils weigh less and are less dense than sands and marls. The absorbing power also varies greatly, strong clays taking up and retaining nearly three times as much water as sandy soils. The temperature of dry soils is usually ten degrees higher that than of wet soils. A dry soil may have a temperature of 90° to 100° F. when the thermometer registers 60° or 70° F. in the shade in the air above it. By *capillary action* water rises from ten to eighteen inches in different kinds of soils. Where this action is great, a wet subsoil will render the soil above it cold. *Evaporation* takes place from soils as it does from the surface of water, but its rate varies according to the nature of the soil. A silicious sand, for instance, loses its water three times as rapidly as a clay soil. All soils diminish in bulk or shrink more or less in drying. Sand scarcely shrinks at all, while peat loses one-fifth of its bulk. Clay, in shrinking, cracks; a property that is of great service in draining cold, retentive soils. *Absorption of moisture from the air* by soils takes place at night, when they extract from it a portion of the water they have lost by evaporation during the day. This power, however, varies in different soils, as do all other physical characteristics, sand absorbing the least and peat the most.

WATER IN THE SOIL.—Water in the soil is principally derived from rain or snow, which, falling on the surface, sinks into the ground until it meets with either an impervious stratum or with the upper level of the "ground-water," after which its movements are governed by identically the same laws as those affecting the flow of water on the surface of the ground. Moisture in soils is that condition in which the pores of the particles (already described) are filled with water. The term "ground-water" is applied to the water filling the interstices between the particles. This ground-water may be likened to a vast subterranean lake; its level constantly rises and falls as a consequence of the influx of surface-water, evaporation, influence of the tide, and many other causes. The height of the "plane of saturation," as the surface of the ground-water is called, is shown by the depth of the surface of the water in wells below the ground. This is not always a certain indication, as local causes at times influence the height of water in wells. Friction in the pores of the soil retards the flow and gives an inclination to the plane of saturation, varying with the nature of the geological formation, but in all cases as great as that of the streams flowing along the adjacent lines of natural surface-drainage. The inclination of the plane of saturation is about fifteen feet per mile in chalk; in sand, as on Long Island, N. Y., it is between five and eight feet per mile. When the slope is less than that of the adjacent stream, the stream dries up. That ground-water is constantly flowing into streams throughout their entire course was shown by a series of measurements of the Cache la Poudre River, Colorado, made by G. G. Anderson in connection with irrigation-works. The inflow from the ground, in a distance of forty miles in which no tributaries entered the river, no allowance being made for evaporation or other loss, was sixty-eight per cent. of the quantity of water flowing in the river at the head of the section under examination.

The inclination of the surface of the underground water is independent of the position of the underlying strata or of the inclination of the surface of the ground.

"The rapidity with which rain-water sinks through the soil evidently varies with circumstances; in rather dense chalks it has been supposed to move three feet downward every year; but in the sand its movements must be quicker" (Parkes).

The quantity of water the soil will absorb from rain is dependent on: 1, The character of the soil, whether porous or otherwise; 2, the inclination of the surface, a steep slope allowing the water to pass off rapidly, while a more gentle slope gives time for it to be absorbed by the ground; 3, the quantity of water already in the soil; 4, the character of the rainfall, whether gentle and not overtaxing the absorbing power of the soil, or heavy and flooding the surface and passing rapidly to the nearest water-course; 5, the season of the year, evaporation being more rapid in summer than in winter.

The temperature of the ground-water approximates the mean temperature of the atmosphere for the year.

The evidences of a saturated soil are: 1, Wet spots on dry land; 2, cracks and fissures of the surface in dry weather; 3, a wet condition of the land remaining after rains.

The disadvantages of an excess of moisture in the soil, as given in the Second and Third Reports of the Metropolitan Sanitary Commission, are:

"1. Excess of moisture, even on lands not evidently wet, is a cause of fogs and damps.

"2. Dampness serves as a medium of conveyance for any decomposing matter that may be evolved and adds to the injurious effects of such matter in the air; in other words, the excess of moisture may be said to increase or aggravate atmospheric impurities.

"3. The evaporation of the surplus moisture lowers the temperature, produces chills, and creates or aggravates the sudden and injurious changes or fluctuations of temperature by which health is injured."

"The influence of humidity of the soil on diseases usually affected by this condition seems to be very much modified in localities with a stratum through which salt-water freely percolates, such as the flat, sandy sites of some sea-side towns. Investigations have determined this

point, at least so far as phthisical complaints are concerned. The principal reason assigned is the free circulation of the water through the pores of the soil, caused by the alternate rise and fall of the tide, whereby stagnation of water and changes in the soil, which would otherwise occur, are prevented. The peculiar character of the water and the conditions of the atmosphere may have some modifying influence. In such places deep subsoil drainage is impracticable, even by the aid of pumping" (Ford).

WELLS are devices for reaching or collecting ground-water to be used for the wants of man. Water cannot be drawn from wells unless they are deep enough to reach the level of saturation in the soil. For this reason wells vary in depth. All the conditions affecting the purity of the soil affect also the purity of the well-waters of that locality, for well-water is ground-water. Wells may be likened to a drain set on end, into which the ground-water flows from all directions. The soil thus drained resembles a cone in shape, with its apex at the bottom of the well and its base at the surface of the ground. The distance from which wells draw water depends on the porosity of the soil, on the depth below the plane of saturation to which they are carried, and on the draft made on them by man. In sand, the water of a well has been affected at a distance of three hundred feet from the source of contamination. The less rain there is, the lower the plane of saturation sinks, and the greater, then, will be the distance from which a well will draw its water. Hence it is that in droughts there is more danger of pollution than during rainy seasons. Fox, in his "Sanitary Examinations of Water, Air, and Food," says: "The water of wells is greatly influenced (1) by the height of subsoil water, which is always varying; (2) by the amount of water that is passing through the subsoil of a country; and (3) by heavy downfalls of rain or periods of drought. I have many times found a water pure at one time and impure at another, and this occasional pollution of a water is often due to the periodical washing of filth into a well by heavy rains. The disagreement in the opinions of able analysts inspecting the purity of samples of water, taken perhaps within a short interval of time from the same well, is often due to these causes, which are not sufficiently recognized."

In a series of exhaustive experiments on the supply of wells, made in 1884, by J. C. Hoadley, C.E., it was demonstrated that the quantity of water available was the same whether it was pumped from an open well or from an iron tube driven into the ground to the same depth. It was also shown "that the convergent flow of ground-water not already in contact with the exterior surface of a suction pipe, from any point or from all points, toward and up to wetting contact with such pipes, is due alone to gravitation acting upon a slope toward a depressed surface produced by drawing water out of the pipe and from immediate contact with its outer surface. The sole impelling force is the earth's gravitation. An obstructing force, in addition to the viscidity of water—namely, the interstitial friction of the soil—retards the water-flow, and causes the water surface to take a sensible slope, steeper as the interstitial friction is greater, less steep as the friction is less."

Von Fodor, in order to determine the effect of natural waters on animals when injected hypodermically, subjected rabbits to the influence of comparatively pure well-water, impure water, and sewage. The symptoms produced were wide fluctuations in temperature, with diarrhœa, varying with the impurity of the water. These experiments seemed to show that although the most impure waters, in themselves, possess but slight infecting power, their effect on the individual must be to derange the system and undermine the health and predispose to attacks of disease.

Wells of fresh water near the sea-shore are supplied by the flow of fresh water underground on its way to the sea. The greater pressure of the ground-water, due to the altitude of its gathering-grounds, prevents the passage of sea-water into the soil. Springs of fresh water have been found, forcing their way to the surface, far out at sea. Nichols asserts that "the freshness of the water is not due to the removal of saline matter from infiltering salt-water, and the rise and fall of the water of such wells with the tide is due to the indirect influence of the tide in offering more or less resistance to the outflow of ground-water."

SPRINGS are the natural outbursts of subsoil water in motion, on the surface of the ground. They exist under one of three conditions:

1. The outcrop of a porous or "water-bearing" stratum between two impermeable strata. The water absorbed by the porous stratum at a greater elevation (it may be miles away) is confined in its flow underground by the impermeable strata above and below, until the lower outcrop is reached, when it flows out over the surface as from a pipe.

2. The outcrop of the rim of a depression in an impervious stratum, or "punch-bowl," over which the ground-water, collected in the cavity, flows on the surface.

3. At the base of a hill the inclination of the surface of the plane of saturation becomes suddenly less, the friction in the pores of the soil exerts a greater influence on the velocity, and the ground-water, being unable to pass off entirely through the soil, is forced to the surface by the pressure of the water behind it on the slope.

Springs of the second and third classes are far more liable to be polluted than those of the first class, and in sanitary examinations, considerations that apply to wells should with equal reason be applied to them.

AIR IN THE SOIL.—The intestices between the particles of soil situated between the level of the ground-water and the surface of the ground are filled with air, the quantity of which is dependent on the porosity of the soil. This air being free to move in every direction is in constant motion. As the level of the ground-water sinks, air is drawn into the pores of the soil; as it rises, the air is forced into the atmosphere to make room for the incoming water. "The diurnal changes of heat in the soil," the state of the winds and of the atmosphere, are all factors in this movement. The composition of this air varies greatly in different localities and under different circumstances. As a rule, however, it is very rich in carbonic-acid gas, besides containing marsh gas and some sulphuretted hydrogen. To determine the composition of ground-air and the laws governing the distribution of its elements, Professor W. R. Nichols, in 1875, made a series of experiments in the "Back Bay" district of Boston, Mass., on land made by filling in large areas of mud flats. He says, "The gaseous products of decay which might be expected to be produced from such a mixture of animal and vegetable matter are sulphuretted hydrogen, ammonia, carbonic acid and marsh gas; the first, sulphuretted hydrogen, was not detected even in the air taken fourteen inches from the surface of the ground, *i.e.*, less than six inches from the top of the decaying matter; ammonia was not found in any appreciable amount; there seemed to be a small amount of marsh gas formed, and of carbonic acid a very large quantity was produced. The amount of carbonic acid was greatest in the neighborhood of the decaying matter, and decreased in amount toward the surface of the ground." The observations were repeated at a later period, and showed that the amount of carbonic acid was steadily decreasing, and that marsh gas had entirely disappeared, due probably to the gradual resolving of the organic matters into their elements by the action of oxygen. The effect of diffusion into the atmosphere was shown by the fact that "at a few feet from the ground no excess of carbonic acid could be detected." Other experimenters have found that while the carbonic acid increases with the depth below the surface, the oxygen in the ground-air decreases, so that "at a depth of four metres (thirteen feet) the air would be irrespirable, and would extinguish a light."

To prevent the entrance of ground-air into a dwelling is a matter of the greatest importance. The usual method is to coat the floor of the cellar with cement, concrete, asphalt, or coal-tar pitch. It is a fallacy to suppose that the first two substances accomplish the purpose; they are porous, and the writer's experiments show that

they have little effect in preventing the ingress of ground-air. The last two are, however, admirable for the purpose, as they are impermeable. No building should be erected without a damp-proof course, and the outer-face of the walls below the surface of the ground should be coated with coal-tar pitch. In damp soils it is well, in addition, to lay a tile drain entirely around, and distant some five feet from the house, at a sufficient depth to be below the foundations and to intercept the water in the soil before it reaches the walls. Bailey Denton recommends that a narrow area should be constructed entirely around the building to the depth of the footing courses of the foundations.

The experiments above mentioned are cited to show how greatly contaminated ground-air may become by the presence of decomposing organic matter, and from what has been seen in regard to the movement of the air, it can be readily understood how important it is that ground in the vicinity of dwellings should be as pure as possible.

Chemical Action of Soils.—The action of soils, except the hottest and driest, on animal refuse, as sewage, for example, is to convert the carbon, hydrogen, and nitrogen into carbonic acid, water, ammonia, nitrates and nitrites, and fatty hydrocarbons; most of the sulphur unites with the iron in the soil. "All these compounds are eagerly absorbed by vegetation." If the organic matter is covered constantly with water, decomposition takes place with extreme slowness.

Water in the soil holds in solution organic and saline substances. Piefke has shown that in the passage of surface water for a considerable distance through sand or gravel, the organic matter is gradually destroyed by the action of the undissolved oxygen in the pores of the soil. The experiments of the Rivers Pollution Commission of Great Britain, and of Nichols and other investigators, have proved that the action of sand and gravel on the *saline* matter is *nil*, except in the case of substances that are susceptible to chemical change under these conditions. Bicarbonate of lime, for example, may part with some of its carbonic acid, and deposit carbonate of lime in the pores of the soil.

As an illustration of the purifying qualities of soil may be mentioned the fact, said to have been learned from Indians, that "the fetor of the skunk can be removed from clothing by burying it in the earth."

In connection with the chemical action of soils, the difference between discharging sewage into cesspools and discharging it a few inches below the surface of the ground, as in sub-surface irrigation, should be borne in mind. In both cases are present the four factors in the production of decomposition: heat, air, moisture, and the presence of decomposable organic matters. In the latter case there are two powerful and beneficial agencies at work, active oxygen and vegetation; in the former neither is present, and the products of decomposition, under conditions favorable to the propagation of disease-germs, are allowed to pass away unchanged; the gaseous by diffusion into the atmosphere, and the liquid into the ground-water, to come to the surface once more in water drawn from the nearest well.

Mechanical Action of Soils.—One of the most important characteristics of soils from the sanitary point of view is their filtering capacity, or their ability to eliminate foreign matters, especially low vegetable organisms, from either water or air.

As mechanical filters, soils, and especially sand and gravel, have been used for years; but it is well known that after a time they become saturated with the material retained and then cease to operate. In such a case the passage of comparatively pure water through the saturated filter so taints it that it becomes unfit for use.

In order to study this filtering capacity of soils, Professor Raphael Pumpelly made, in 1881, a very exhaustive series of experiments, which appeared in supplement No. 13 of the *National Board of Health Bulletin*. The points brought out by this investigation were:

"1. The rate of flow of water and of air under given conditions.

"2. The capacity of soils as filters in eliminating organic and inorganic substances from liquids.

"3. Their capacity as filters in eliminating the living low forms of vegetable life, both germs and adult organisms, from ground-water and ground-air."

The bearing of these experiments on health is clearly put by Professor Pumpelly at the beginning of his report.

"When we consider that every vault, cesspool, and cemetery is a centre of pollution to the ground-water which supplies our wells, and, to a certain extent, also the reservoirs for cities, we can appreciate the importance of ascertaining to what extent soils are capable of eliminating the injurious properties contributed by the pollution.

"Through the cellars our houses become, especially in winter, the ventilating chimneys for the surrounding ground, sucking in from all directions the air that has been nearly stagnant in the pores of the soil during the summer. In view of the fact that the ground-air is polluted by vaults, cesspools, and cemeteries in the country, and by the garbage of made ground and defective drains and sewers in cities, it is important that we should determine the extent to which different soils are able to filter the injurious properties out of the air passing through them."

The test employed in these experiments was the rapidity with which an infusion of beef was infected by either air or water passed through the filtering material, which had previously been sterilized. The filters used were sand, charcoal, animal charcoal, asbestos, a mixture of sand and kaolin, kaolin, coal ashes, and loess.

The result of these experiments, as given on page 18 of the Supplement, "shows conclusively the utter worthlessness of sand as a filter for germinal matter," "nor do the sandy or even clayey soils afford us a safeguard against germ-contamination of our well waters, as the experiments with loess, clay, and clay mixtures would probably justify us in concluding, although it must be admitted that we have not here strictly the same physical conditions as in a natural soil which has not been subjected to heat."

"Not only does the amount of radiation differ in different soils, but a change is produced in the heat by the kind of soils. The remarkable researches of Tyndall have shown that the heat radiated from granite passes through aqueous vapor much more readily than the heat radiated by water (though the passage is much more obstructed than in dry air). In other words, the luminous heat rays of the sun pass freely through aqueous vapors, and fall on water and granite; but the absorption produces a change in the heat, so that it issues again from the water and granite changed in quality; it will be most important for physicians if other soils are found to produce analogous changes" (Parkes). "With regard to the effect of temperature of the soil on disease, it can hardly be doubted that it powerfully influences malaria, and probably also aids the progress of cholera."

Pollution of the Soil.—Having described at some length the characteristics of soils and of the water and air that they contain, the innumerable causes of pollution will be readily comprehended. Dr. Ford, in Buck's "Hygiene," divides them into four groups: 1, Excreta; 2, interments; 3, coal gas; 4, surface pollution.

1. Pollution of the soil by excreta is the most frequent and most dangerous of all causes. Broken sewers and leaking cesspools allow liquids saturated with decomposing animal matter to pass into the soil and contaminate both ground-air and ground-water; the latter in all probability to drain into some well, with results that have already been described.

2. The drainage from cemeteries is liable to pollute the water of wells and springs, and it has been shown that, in one or two instances, injury to health has been produced.

3. Soil pollution by coal gas is met with only in large towns and cities; there, however, it is of constant occurrence. Severe illness, somewhat resembling typhoid fever, has been caused by this.

4. The causes of surface defilement are too numerous and too well known to require enumeration. Among them may be mentioned manure heaps, pig-styes, dirty streets, collections of refuse, badly constructed slaughter-houses, etc.

DISEASES AFFECTED BY SOIL.—The diseases influenced by the condition of the soil are: Consumption, paroxysmal fevers, typhoid fever, cholera, dysentery, diphtheria, yellow fever, bilious and remittent fevers.

Consumption is greatly affected by excess of moisture in the soil; in fact, this may be said to be one of its prominent causes. Since the announcement of this relationship, years ago, all observations have gone to prove its truthfulness, and at the present it is so thoroughly understood that space will not be wasted in detailed explanations. A reduction in consumption frequently follows the introduction of systems of sewerage in towns, by which the drainage of the town site is an incidental result. In this way the general death-rate of Newport, South Wales, was reduced twenty-three per cent., while that from phthisis was reduced thirty-two per cent. At Salisbury, England, the general death-rate was reduced nine per cent., and that due to phthisis, forty-nine per cent. Although such gratifying results have attended the introduction of sewers, it is unsafe, for reasons that will be given further on, to combine sewerage with soil drainage. Each should be effected by pipes entirely independent of the other.

Malaria.—One of the most potent factors in the production of malaria is soil moisture; decomposing organic matter must also be present, even if only in small quantities.

The effect of soil moisture and drainage on malarial fevers is very curiously illustrated in the case of the irrigated lands of California. These lands are divided into four general classes:

1. Uplands. The soil is a gravelly clay which, owing to the regular slope of the surface, "remains moist but not water-soaked after irrigation." These lands are almost entirely free from malaria.

2. River bottoms of sand or alluvium, with a subsoil of coarse gravel and a fair surface slope. "The lands of the second class show its existence, but not to a sufficient degree to form a marked feature in the endemic causes of disease. . . ."

3. The sandy bottoms of the San Gabriel River, having the same general characters as Class 2, but having a much less rapid slope, the level of the ground-water being much nearer the surface. The lands of this class "show the presence of malaria in a notably active form, giving a well-marked type to the summer diseases."

4. Cienaga lands or open plains, with a heavy soil of the adobe type, "with occasional springs and bogs, with natural ponds of water," in winter very wet, and in summer irrigated extensively by artesian wells. These lands "develop, with irrigation, a very active form of malaria, the disease being largely of a pronounced malarial type and running often a severe course." The following tabular statement will serve to show the connection between the soil, the malaria, and the drainage of the irrigated lands in California.

Lands.	Class 1.	Class 2.	Class 3.	Class 4.
Distance from ocean	Great.	Considerable.	Slight.	Slight.
Summer temperature	High.	High.	Moderate.	Moderate.
Slope	Considerable.	Slight.	Very little.	Slight.
Subsoil	Pervious.	Pervious.	Pervious.	Impervious.
Effect of irrigation	No malaria.	Considerable malaria.	Malaria.	Much malaria.
Effect of drainage	(No drainage.)	Malaria disappears.	(No drainage.)	Malaria disappears.

"The whole history of irrigation in Southern California goes to impress this lesson: that to escape malaria, drainage must go hand in hand with irrigation; that unless it does, the water which brings wealth brings also disease and death."

Typhoid Fever.—The spread of this disease is caused principally by impure air and water in the soil. Frequent fluctuations in the plane of saturation force ground-air, loaded with the products of the decomposition of organic matter, and carrying with it the germs of the disease, into the atmosphere, to be taken into the system in breathing. Water from wells and other sources of supply is contaminated by the infiltration of polluted ground-water, which, if carrying germs of disease, becomes the vehicle of spreading the contagium. Typhoid fever becomes more prevalent as the quantity of water in the ground diminishes, and gradually disappears on the return of wet seasons. The introduction of systems of water-supply and sewerage in towns materially reduces the mortality from disease.

The relation between ground-air and ground-water and typhoid fever is receiving such constant illustration in practice that more than the mere statement of the facts is unnecessary.

Diphtheria.—Although lack of drainage of the subsoil has not been shown to be the cause of diphtheria, there is no doubt that it is a powerful factor in its production under certain conditions. The disease begins to show itself after a long season of dry weather, when the rains begin, and the level of the ground-water is gradually raised. The following case seems to show that diphtheria may be propagated by water: Dr. R. C. Newton, U.S.A., describes the results of drinking polluted water from two wells near an army post at the West. The wells were sunk "in the most advantageous position to receive the drainage of two filthy cattle yards." In the house supplied with water from one of these wells were five children, four of whom were attacked, three dying. The fifth, the child of a servant in the house, was not allowed by its mother to drink the water and was not attacked. In the family using the other well were a man, his wife and two young children, one a baby eighteen months of age. The father was generally away and was not attacked. The mother and oldest child had chills, and the baby was attacked with diphtheria, but recovered. A careful examination showed that neither of these families could have been exposed to the contagion of diphtheria.

Cholera may be propagated by the pollution of sources of water-supply. This was illustrated during a recent outbreak of the disease in Spain. Madrid, Seville, and Barcelona have pure water-supplies, and, although cholera appeared, it did not gain headway and soon disappeared. The towns of Aranjuez, Valencia, and Granada, on the other hand, depend largely on wells for their water-supply. All suffered severely from the epidemic.

Although both ground-air and ground-water are considered active agents in producing certain specific diseases, as typhoid fever, etc., it nevertheless remains that the fluctuation of the water level is absolutely necessary for the development of these diseases. Pettenkofer has shown that changes in the level of subsoil water are the certain forerunners of epidemic outbreaks of both cholera and typhoid fever; while Baldwin Latham goes so far as to say that the excremental pollution of a soil is "inoperative in producing epidemic disease" if unaided by fluctuations in the plane of saturation. It must not be understood from this, however, that all fluctuations of subsoil water are dangerous to health. Provided the water is constantly moving, very healthful results may be produced by a fluctuation of level, aiding as it does the aëration of the soil. It is the rising and falling of stagnant water that is so pernicious. Acting on these principles, Mr. Latham was able to predict an outbreak of typhoid fever in an English town, which occurred in a violent form three weeks after his notice to the authorities, warning them to be on their guard.

HEALTHFULNESS OF LOCALITIES.—As has already been seen, there are many factors that go to make the healthfulness of localities, making prediction in many cases a matter of great uncertainty. There are, however, certain physical features of the earth's surface that, as has been

shown by experience, may be taken as fair indications of the salubrity of the locality in which they occur. Among these may be classed:

Healthy Localities. Near the top of a slope; a "saddle-back;" sands and gravels; granite; metamorphic and trap formations; slate; sandstone formations; salt marshes, etc.

Suspicious Localities. Gravels and sands filled with water; clay; dense marls; alluvial soils, etc.

Unhealthy Localities. Enclosed valleys; "punch bowls" or depressions in impervious strata; locations among hills where the air is liable to stagnate; ravines—"the worst ravine is a long narrow valley, contracted at its outlet so as to dam up the water behind it;" plains at the foot of hills; depressions in plains; fresh-water marshes at any altitude; soils containing much organic matter and exposed to alternate wettings and dryings; made soils, etc.

Proximity to ponds and streams does not of necessity render a locality unhealthy. If the water is pure and stagnation does not occur, they will not be detrimental to health. If, on the other hand, the surface of a pond is subject to fluctuation in level, whereby large areas of soil are alternately covered and laid bare by the water, evaporation will project into the atmosphere large quantities of impurities from the decaying organic matter in the soil and render the locality unhealthy.

The drainage of a country through its valleys and streams, though naturally good, may be seriously interfered with by the erection of dams, embankments for railroads and common roads, bridge piers, and the like. Unless special precautions are taken, the obstruction of the natural outlets by such works causes the raising of the level of both surface and subsoil water, with the overflow or saturation of large areas of land. An increase in malarial fevers, and in many instances the appearance of these diseases where they were never before known, is the certain result.

Salt marshes are healthy as a rule. If, however, they are underlaid by clay or other impervious strata in which depressions are likely to exist, the ground-water will become more or less stagnant and the locality will be unhealthy.

The filling in of low waterlogged lands, marshes, and similar localities is to be condemned, unless the land is thoroughly drained as a preliminary measure. By filling in without draining, although the level of the ground is raised above the surface of saturation, all other conditions remain the same, and a locality already unhealthy is rendered more so.

All the benefits of a healthy locality may be nullified by a damp cellar. In an examination recently made by the Wisconsin Board of Health, it was discovered that seventy-five per cent. of the cellars in the cities, towns, and villages of that State are either "habitually damp or damp in rainy weather."

Granite, trap, and metamorphic rock, if the slope of the surface is great, allowing water to run off rapidly, make healthy localities. If, however, they contain cracks, "faults" or depressions, ground-water collects in them and, being unable to flow away, stagnates, and malarial conditions are the result.

Limestones also make a healthy locality, when the surface-slope is steep. Marshes, however, are of frequent occurrence, owing to the retention of ground-water in cavities that have been gradually hollowed out by the action of the carbonic acid in the rain falling on them.

Chalk, if free from clay, is said to be healthy. Chalk marl is impermeable, cold, and unhealthy. "Some of the most unhealthy districts in America are on chalk."

Sandstones are usually healthy. If, however, the formation is a thin stratum superimposed on one of an impermeable character, it becomes unhealthy.

Clay is one of the most unhealthy of soils. Ridges of clay are cold and every depression is a marsh.

"Gravel is the healthiest of all sites" (Parkes). Both sand and gravel are extremely healthy when there is no obstruction to the flow of the ground-water through them. They become unhealthy when underlaid by impervious strata, or when they contain decomposing organic matter. Sand and gravel, when containing impurities, are perhaps more unhealthy than less porous soils, as the passage of water and air through them causes the contaminating influence to spread to great distances.

Alluvial soils are unhealthy, as the atmosphere above them is rendered moist by the rapid evaporation; they contain large quantities of organic matter, and there are numerous marshes, especially when the soils are interspersed with clay or other impervious formation.

With the knowledge now in our possession, there is no excuse for building in an unhealthy locality or on an unhealthy site; particularly is this true of isolated buildings where the surrounding ground is under the exclusive control of the owner. In urban districts there is more excuse, but, even there, much may be done to increase the salubrity of the individual houses, if general improvements are impossible.

Vegetation exerts a powerful influence on the health of localities. Marsh miasma is intercepted by a forest, so that "persons living in localities so screened are exempt from attacks of malarial fever." The eucalyptus-tree is a remarkable prophylactic against malaria. The effects of trees on the atmosphere and the soil are: 1. To modify the extremes of temperature. 2. To prevent floods. 3. To aid the drainage of the soil.

Trees are a disadvantage when they are so dense as to prevent the free circulation of air, and when so close to a house as to materially obstruct the sunlight. In temperate climates, under these circumstances, they render a house damp. The fibrous roots of trees oftentimes are of great benefit; traversing the soil in every direction, they increase its porosity and improve its drainage. Vegetation also seizes on and appropriates to its own use organic matter that would otherwise, by slowly decomposing, pollute the soil-air and ground-water.

Improvement of Unhealthy Localities.—The methods that may be employed to increase the healthfulness of a site or locality are concisely stated by Dr. Ford as follows:

"1. By thorough surface and subsoil drainage.

"2. By free access of air and sunlight.

"3. By the use of the well-known means to insure perfect dryness of the walls and basement, and the exclusion of ground-air.

"4. By the regulation of vegetation; that is, by removing or planting trees, etc., according to circumstances of soil, climate, etc., etc.

"5. By preventing the pollution of the soil by the use of the best means for carrying off the surface-water, house-water, and all house-offal, as rapidly as possible."

Since, of all the factors that affect the relationship between soil and disease, ground-water is the most potent and the most readily removed, it follows that the under-drainage of land is of the greatest importance. Sir Edwin Chadwick has said: "In considering the circumstances, external to the residence, which affect the sanitary condition of the population, the importance of a general land-drainage is developed, by the inquiries as to the cause of prevalent diseases, to be of a magnitude of which no conception had been formed at the commencement of the investigation. Its importance is manifested by the severe consequences of its neglect in every part of the country, as well as by its advantages in the increasing salubrity and productiveness wherever the drainage has been skilful and effectual."

Drains.—The drainage of land, being more within the province of the engineer than of the physician, will receive but a passing notice. Draining is usually accomplished by small porous, earthen pipes, laid in rows with open joints at a depth of about five feet below the surface of the ground. The rows are usually laid in the direction of the steepest slope and between thirty and sixty feet apart. The water in the soil overflows into these drains and passes away to a neighboring water-course or other convenient outlet provided for it. When all the water in the soil above the drains has flowed off —which requires a length of time dependent on the po-

rosity of the soil—the level of the surface of saturation will become unvarying and will correspond to the depth of the drains below the surface of the ground. From what has already been said of soils, it is evident that drainage removes the conditions most favorable to the propagation of disease.

In regard to the effect of drainage on the temperature of the atmosphere, the following is taken from "Minutes of Information on Drainage:" "A farmer, being asked the effect on temperature of some new drainage-works, replied that all he knew was, that before the drainage he could never go out at night without a great-coat, and that now he could; so that he considered it made the difference of a great-coat to him."

Drainage-works, while in course of construction, may in certain cases cause outbreaks of fever, which, as soon as the drains begin to do their duty, gradually subside, and at last disappear. A case of this kind, cited by Douglas Galton, occurred in India in 1860, when the peninsula of Kowloon was occupied by the British troops as a sanitarium. Although it was of granite formation and freely exposed to the winds, the troops suffered severely from fever, which was attributed to "the disturbance, in a tropical climate, of the surface of soil impregnated with decaying organic matter." After a time the fever subsided and did not reappear.

The drainage of a town should be entirely separate and distinct from the sewerage. Sewers need not be very far below the surface; but drains should be laid as much as fifteen feet below, to insure the drainage of the deepest cellars. The inverts of sewers are often made hollow to convey away the water that is liable to accumulate in the trenches during construction. These drain the subsoil to a certain extent; but they are not to be desired, as, owing to leaks, they are likely to carry as much sewage as subsoil water. Then, again, sewers are obliged to follow certain lines of grade, while drains, to be most effective, as before stated, should be laid in the direction of the steepest slope. Sewers have sometimes been the occasion of malarial diseases by damming up underground waterways by the trench-fillings, which are more or less puddled and therefore impervious.

If the sewers themselves are intended to drain the subsoil, they must of necessity be made so as to allow the water to enter. This it will do in wet weather, when the head of water outside is greater than that inside the sewer. But during dry weather the reverse will be the case, and the soil will become saturated with sewage. Even should the sewer carry nothing but clear water, the fluctuations in the level of the surface of saturation caused by the above, would produce conditions favorable to the development of disease.

If malaria reappears after works of drainage have been instituted, there is some good and usually removable cause for the occurrence. Mr. William Marshall tells of the reappearance of ague in the Fens some time after it had ceased to exist, though in the *autumn*, instead of the *spring* of the year as formerly, and explains it by the fact that "the drainage had been carried beyond the point of prudence, so that in the summer months, and especially toward harvest, the Fen ditches became *nearly dry*, and the consequence was that we once more got an exhaling surface and a noxious effluvium arising from decaying vegetable matter. This state of things is now quite altered, and the ague has vanished, owing to the farmers making it a rule to let water in from the rivers during the summer months, so as to 'keep a water' always in the Fen ditches."

Examination of Localities.—Dr. Parkes gives the following method for examining a locality:

"1. *Conformation.*—Height above sea-level and elevation of hills above the plain. (Determine by mercurial barometer or aneroid, or, if possible, get the heights from an engineer.) Angle of declivity of hills; amount of hill and plain; number, course, and characters of valleys and ravines in hills; dip of strata; geological formation; water-sheds and courses; exposure to winds; situation, amount, and character of winds; sunlight, amount and duration; rain, amount and frequency; dust.

"2. *Composition.*—Mineralogical characters. Presence of animal or vegetable substances; amount and characters.

"3. *Covering of soil* by trees, brushwood, grass, etc.

"4. *Points for Special Examination.*—Amount of air; of moisture. Height of subsoil water, at the wettest and driest seasons. Changes in level, and rapidity of change of subsoil or ground-water. Condition of vegetable constituents; examination of substances taken up by water, etc."

Frederick N. Owen.

SORRELL (*Oseille commune*, Codex Med.). *Rumex acetosa* Linn., order *Polygonaceæ*. This, the common Sorrell of Europe, is a larger plant than our Red Sorrell, and has more divided leaves, but its properties are practically the same. Both contain oxalic salts, which give a pleasantly sour taste to the herbage, and both have bitter roots. Sorrell has been used as a diuretic, and as a pleasant salad, or flavor for soups. It has no medicinal value.

Allied Plants, etc.—See Rhubarb, Dock, etc.

W. P. Bolles.

SPA, or Spaa, situated in Belgium, not far from the Prussian border, was formerly one of the most popular and fashionable watering-places on the Continent, being a favorite resort with the nobility of all Europe. It lies at an elevation of about one thousand feet above the sea; the climate is not particularly mild, and sudden changes of temperature are common. There are eight chalybeate springs of which therapeutic employment is made, which are known respectively as the Pouhon, Géronstère, Groesbeck, Barisart, Dundas, Sauvenière, Tonnelet, and Prince de Condé. The following is the composition of the Source de Pouhon. A litre of water contains:

	Gramme.
Sodium bicarbonate	0.1266
Potassium bicarbonate	0.0105
Magnesium bicarbonate	0.1674
Calcium bicarbonate	0.1730
Ferrous bicarbonate	0.0714
Sodium sulphate	0.0203
Sodium chloride	0.0256
Silica	0.0629
Total solids	0.6577

The waters are athermal. In addition to the water, employed in the ordinary ways, mud-baths are often prescribed. The principal indication for a course of treatment at Spa is anæmia. The season extends from the first of June to the middle of October. *T. L. S.*

SPANISH FLIES (*Cantharis*, U. S. Ph.; Br. Ph.; *Cantharides*, Ph. G.; *Cantharide*, Codex Med.). This rather inaccurate name is given to *Cantharis vesicatoria* De Geer (*Lytta vesicatoria*), order *Coleoptera*, a brilliant green beetle, with a long, cylindrical body, a disagreeable odor, and powerfully irritant properties. It is about an inch in length, and from one-fifth to a fourth in breadth. It has a good-sized, ovoid, heart-shaped head, filiform, black antennæ of eleven joints, a distinct, rounded thorax, and long, straight wing-covers. Legs provided with five tarsal joints, excepting the two posterior ones, which have only four. Wings large, brown, translucent. The odor, even when long dried, is strong and characteristic. Its larva is yellowish-white, soft, elongated, thirteen-jointed; it has a rounded head, short antennæ, and stout jaws; there seems to be uncertainty whether it feeds

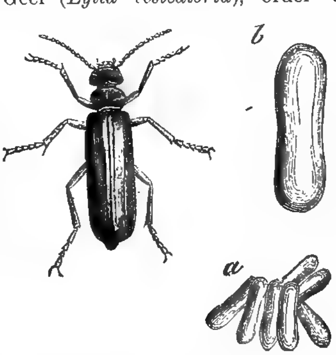

Fig. 3562.—Blistering Beetle, Natural Size; *a*, Eggs, somewhat enlarged; *b*, a single egg, greatly enlarged. (Moquin-Tandon.)

upon roots, honey, bees, or other insects. The perfect beetle appears in great numbers in its native countries, about the middle of summer, upon poplars, ashes, lilacs, privets, and even upon roses and several other domestic shrubs, whose leaves it devours. The acrid effluvium emitted from it can be smelled at a considerable distance, and when the insects are abundant, it is said to be dangerous to persons sitting under the trees where they are.

This beetle is a native of Southern and Middle Europe, Western Asia, etc. It is abundant in Spain, France, Germany, Italy, etc., and in these countries is collected for use. During the middle of warm days it is very active and alert, but in the night and early morning, benumbed by cold and wet, it is very heavy and clumsy. Advantage is taken of this time for collecting the beetles, when they can be beaten or shaken from the shrubs where they hang and caught in sheets or bags held under the boughs. They are then killed by boiling water, steam, vinegar, ether, or some such treatment, and carefully dried by moderate heat.

The drug, as usually found in the market, consists of these bodies whole, excepting what the friction of the transportation has done in the way of rubbing off the antennæ and legs. Ground, it gives a disagreeable-smelling, grayish powder, sprinkled with bright metallic-green specs—the fragments of wing-cases and body. Taste, resinous and acrid.

Blistering beetles were known to the ancients, and have been used for centuries in many different countries, but they have not been generally of this particular species, whose employment is comparatively modern. This, however, from its abundance, and the ease with which it can be collected, as well as on account of its quality, has generally supplanted the others in English and American commerce, at least.

Composition.—A great variety of ordinary animal products, nitrogenous tissues, fat, oil, watery extract, etc., and about one-fourth to one-half per cent. of a well-defined, crystalline, active principle named *Cantharidin.* This energetic poison crystallizes in tables or flakes, is white, colorless, and odorless, and at first has but little taste. It dissolves in twenty-five parts of water, and in upward of three thousand of alcohol; in ether and chloroform it is almost insoluble. Cantharidin is about thirty times as active as cantharides.

Action and Uses.—Cantharides is an intense irritant, whether applied internally or externally; taken into the stomach, it causes heat and burning of the fauces on its way down, then vomiting, often of bloody mucus, intense pain and burning of the stomach and bowels, diarrhœa, fibrinous and bloody stools, and finally urinary distress, strangury, bloody urine, and other evidences of renal and vesical irritation. The genitals are also excited—priapism in the male, swelling of the vulva, etc., in the female; uterine tenesmus or abortion may follow. Erotic sentiments may be, but are not necessarily, aroused. A small, quick pulse, rapid breathing, a hot, dry skin, headache, delirium, coma, and death may follow its introduction. Two grams (30 grs.) of powdered cantharides, or five centigrams ($\frac{3}{4}$ gr.) of cantharidin, would be a dangerous dose. Applied externally, cantharides produces, after a few minutes, redness and slight burning of the skin, followed, in from one-half to five or six hours, by small blisters just beneath the cuticle, which rapidly separate it from the skin and soon coalesce into one large bleb over the whole surface covered by the blister. A small amount of cantharidin is absorbed through the skin, as strangury, hæmaturia, etc., are rather apt to follow very extensive blistering. This medicine, like most active substances, has been given in a great variety of conditions—vesical catarrh, gonorrhœa, dysuria, incontinence of urine, and as a general nervous stimulant. For none of these things is it now in vogue. Externally applied, it is the safest, surest, and in all ways the best vesicant known; easy, comparatively painless, and superficial; never leaving a scar. Large and repeated blisters were formerly used, with a view of "drawing off" serous effusions from the pleura, peritoneum, the joints, etc.; but as derivative effects are not accomplished in so simple and direct a way, it is now principally used as a means of simple counter-irritation.

Administration.—If it is desired to give *Cantharides* internally, the Tincture (*Tinctura Cantharidis*, U. S. Ph., strength, $\frac{6}{100}$) is a suitable form, but the numerous cerates and liniments which follow, show how almost exclusively it is employed externally: *Ceratum Cantharidis*, U. S. Ph., strength, $\frac{35}{100}$; and *Ceratum Extracti Cantharidis*, U. S. Ph., strength, $\frac{30}{100}$; as well as *Charta Cantharidis*, strength, $\frac{1}{17}$, are used for blistering. Liniment of Cantharides, *Linimentum Cantharidis*, U. S. Ph., (fifteen per cent.), is moderately stimulating; and the *Collodium cum Cantharide*, U. S. Ph., (Blistering Collodion), containing sixty per cent., is a fairly active blister, if applied thickly with a brush. For the last dozen years or more the cantharidal cerates of the Pharmacopœia have been almost superseded by a Cantharidal Plaster, prepared upon a large scale by manufacturing pharmacists, with a rubber basis instead of the simple fatty one of those. It is scarcely as uniform or quick in its action as the others, but on account of its convenience, its durability, and ease of handling, it is likely to continue in use. The Tincture of Cantharides, considerably diluted, is a frequent ingredient of "hair renewers" and other cosmetics.

Allied Animals.—The tribe *Cantharidæ* contains numerous poisonous beetles, whose acrid secretions have been put to use as vesicants. Some of these are even more irritant than Cantharis itself. *C. Vittata*, our Potato Beetle, and other species of *Cantharis, Meloe*, the oil-beetles, several species of *Mylabris* ("M. Chiccorii" the "Chinese blistering fly") are examples.

Allied Drugs.—All local irritants: Mustard, Pepper, etc., Croton-oil, Tartar emetic, Iodine, etc., as well as Turpentine in all its various forms.

W. P. Bolles.

SPARKLING CATAWBA SPRINGS. *Location and Post-office,* Sparkling Catawba Springs, Catawba County, N. C.

Access.—By the Western North Carolina Railroad to Hickory; thence by stage to the springs, six miles.

Analysis (Howe).—The waters are said to be sulphur and chalybeate.

These springs are situated in Western North Carolina, near the Catawba River, at an elevation of one thousand feet, amid the eastern foot-hills of the Blue Ridge, which form in the distance a pleasant feature in the landscape. The hotel accommodations, consisting of several large buildings and cottages, are ample. There are also plunge, shower, and vapor baths.

G. B. F.

SPARTA SPRINGS. *Location and Post-office,* Sparta, Monroe County, Wis.

Access.—By the Chicago & Northwestern, or the Chicago, Milwaukee & St. Paul Railway.

Analysis (J. M. Hirsh).—One pint contains:

	Grains.
Carbonate of soda	0.026
Carbonate ot magnesia	0.503
Carbonate of iron	1 792
Carbonate of manganese	trace
Carbonate of lime	0.050
Carbonate of ammonia	trace
Carbonate of lithia	0.003
Carbonate of strontia	0.002
Carbonate of baryta	trace
Sulphate of potassa	0.080
Sulphate of soda	0 277
Sulphate of lime	0.022
Chloride of sodium	0.018
Chloride of calcium	0.075
Phosphate of soda	0.008
Phosphate of alumina	0.007
Iodide of sodium	trace
Silica	0.035
Total	2.898

Therapeutic Properties. — An unusually strong, chalybeate water.

These springs are situated in the southwestern portion of Wisconsin, two hundred and fifty miles from Chicago.

The town of Sparta, of about two thousand five hundred inhabitants, affords good hotel accommodations.

G. B. F.

SPEARMINT (*Mentha Viridis*, U. S. Ph.; *Menthe verte*, Codex Med.). The flowering tops and leaves of *Mentha viridis* Linn. (*Mentha Sylvestris, glabra* Koch). Spearmint has narrower, more sessile leaves, slenderer and more spike-like flower clusters, smaller flowers, and a different odor from peppermint, which it otherwise closely resembles. It is a European and Asiatic plant, and has been long under cultivation. It grows in the same gregarious way as peppermint. The following officinal description will serve to distinguish it from other mints: "Leaves about two inches (5 centimetres) long, subsessile, lanceolate, acute, serrate, glandular, nearly smooth; branches quadrangular, mostly light-green; flowers in terminal, interrupted, narrow, acute spikes, with a tubular, sharply five-toothed calyx, a light purplish, four-lobed corolla, and four rather long stamens; aromatic and pungent." Spearmint contains a composite oil analogous to that of peppermint, and it is applicable to the same uses. The oil, and a water, and spirit made from it, are officinal.

ALLIED PLANTS, ETC.—See PEPPERMINT.

W. P. Bolles.

SPECTACLES. * *Besicles,* † *lunettes*, French; *die Brille,* ‡ German; *occhiali*, Italian; *perspecillum, conspecillum, vitrum oculare, ocularius*, mediæval Latin—are first mentioned about the close of the thirteenth century. § Seneca mentions the fact that "letters, however minute and indistinct, appear larger and clearer when viewed through a glass globe filled with water," [11] and Pliny notices the use of a sphere of crystal,[12] or glass globe filled with water,[13] as a burning glass. ‖ The first mention of a lens, properly so called, is attributed to the Arabian mathematician Alhazen (*obt.* 1038),[15] who describes the magnifying property of a segment of a sphere of glass.[16] Roger Bacon (*circa* 1267) also mentions the magnifying property of convex lenses,¶ and suggests the benefit to be derived from their use by old persons with weak sight.[18] The step from the use of a convex lens, as a magnifier, to the construction of binocular eye-glasses or spectacles, to be worn by presbyopes in reading, implies a considerable development of the optician's art, in the direction of grinding lenses of relatively long focus. The invention of spectacles is variously attributed to Salvino degli Armati, a Florentine (*obt.* 1317),[19] and to Allessandro della Spina, a Dominican monk of Pisa (*obt.* 1313). The use of concave glasses, similarly mounted in pairs, as a help to myopes in distant vision, must have followed at no very long interval; the date of their first employment is, however, unknown. The necessity for the selection of lenses of different focal length for different persons, as well as for the same person at different periods of life, must also have been very early recognized; but there is no reason for believing that the choice was ever made in any better way than by trying glasses at random, until a pair was found which appeared to be suited to the kind of work for which they were to be used. * Certain it is that spectacles had been in common use for at least a hundred and fifty years before the theory of their action was explained,† and it is only since the middle of the present century that anything like a complete understanding of the subject has been reached.

Spectacle lenses, as late as the eighteenth century, were always, so far as is known, of the plano- or double-convex, or of the plano- or double-concave form.[22] Both the plano-convex and the plano-concave glasses were probably mounted, sometimes with the plane surface and sometimes with the curved surface next the eye. Concavo-convex lenses (menisci), with the convex surface ground to the shorter radius of curvature, were used to some extent in the last century, but with varying practice as regards the side turned next the eye. ‡ [23] Under the name of *periscopic* spectacles, concavo-convex lenses, with the concave surface turned toward the eye, were brought into common use by Wollaston (1804).[24] A special construction of double-convex and double-concave spectacle lenses, made by grinding the two surfaces of the glass to cylindrical curves of equal radii, but with crossed axes, was introduced (before 1830) by Galland de Cherveux;[25] such lenses are still manufactured, but the special advantage once claimed for them, over the several forms of lenses with spherical surfaces, is altogether illusory; their existence in commerce made it possible, however, to furnish a cylindrical surface, on demand, at a time when plano-cylindrical lenses were not yet obtainable. Cylindrical lenses proper, as used for the correction of astigmatism, were first employed by G. Airy, Astronomer Royal (1827),[26] who was himself the subject of compound myopic astigmatism. Airy discussed the relative advantages, in compound astigmatism, of a bi-cylindrical lens of unequal radii of curvature, and a spherico-cylindrical lens; he gave the preference to the latter combination, for reasons which are still generally accepted as

* Chaucer uses the word in the singular number: *a spectakel.*[1]

† From the old French form *bericle*, diminutive of *berille;* Latin, *berillus, beryllus;* Greek, βήρυλλος, the beryl.[2]

‡ From *berillus, beryllus*, βήρυλλος, the beryl; "the colors of the beryl range from blue through soft sea-green to a pale, honey yellow, and in some cases the stones are entirely colorless;" [3] *ocularii vitri aut berillorum:* Guy de Chauliac (1363).[4] The most available material for spectacle-lenses, excepting glass, is rock crystal or quartz, and it is highly probable that this mineral, still largely used under the name of pebble, was the *berillus* of the older opticians; *cf.*, the derivation of "brilliant"—French, *briller*, etc.—from *beryllus.*[5]

§ Spectacles, both convex and concave, were in common use by the Chinese before the opening of commerce with Europe. They were made of a transparent stone, of a color like that of a strong infusion of tea, called *scha-chi* (tea stone), and were tied upon the head by silken cords.[6] Chinese spectacles are now made of rock crystal, and are mounted in heavy frames, evidently borrowed from old European models. Several pairs of Chinese spectacles, of comparatively late fabrication, are preserved in the Museum of the Old East India Marine Society, at Salem, Mass.

The common use of some form of magnifying-glass by the ancients is wellnigh proved by their perfect workmanship, as displayed in the engraving of gems, and a crystal wrought in the form of a convex lens has been actually discovered by Layard, in the ruins of Nimroud.[7] On the other hand, it appears clearly, from the notice on presbyopia and myopia, by Paulus Aegineta (seventh century, A.D.),[8] that they had not applied lenses to the relief of persons laboring under these disabilities.

Pliny's description of the visual defect of the Emperor Nero[9] strongly suggests a case of compound myopic astigmatism, with the meridian of greatest refraction approximately vertical. The statement that Nero was accustomed to view the conflicts in the arena in or upon a smaragdus (Nero princeps gladiatorum pugnas spectabat in zmaragdo),[10] taken in connection with what is said of this gem in the same chapter, would seem to be best explained upon the supposition that the emperor possessed a large and highly polished emerald, very probably of unequal curvature in its two principal diameters, and that he viewed the combatants, in the strong light of the amphitheatre, by reflection from its convex surface. This theory would imply that the use of the gem for this purpose was the result of an observation made by Nero himself, who may, therefore, be accredited with the accidental discovery of an eye-glass suited to the correction of myopia, or of compound myopic astigmatism; the invention would appear to have died with the inventor.

‖ Pliny also mentions the fact that objects seen reflected in a concave mirror appear enlarged.[14]

¶ It has been contended that Roger Bacon may have derived his knowledge of lenses from Flanders.[17]

* Bartisch (1583) protests strongly against the widely spread abuse of spectacles which prevailed at his time.[20]

† "Maurolicus, in his treatise *de lumine et umbra* (1554), considers the crystalline as the principal instrument of vision, and as transmitting to the optic nerve the images of objects; and he explains why some persons are long-sighted and others short-sighted, according to the less or greater convexity of the surfaces of the crystalline, showing that in the former case the rays have not been converged to a focus when they reach the retina, while in the latter they have been converged before they reach it. He explains, also, how the convergency may be hastened in the long-sighted eye by the use of a convex glass, and delayed in the short-sighted by a concave one. These observations of Maurolicus were not known to Kepler, when it was proposed to him, as a question by his patron, Dietrichstein, in what manner spectacles assisted sight? The first answer he gave, as he tells us in his *ad vitellionem paralipomena* (1604), was, that convex glasses were of use by making objects appear larger. But his patron observed, that if objects were by them rendered more distinct, because larger, no person would be benefited by concave glasses, since these diminished objects. . . . He now gave a clear account of the effect of lenses, whether within or without the eye, in making the rays of a pencil of light converge or diverge; and explained, that convex glasses assist the sight of presbyopic persons, by so altering the direction of rays diverging from a near object, that they fall upon the eye as if they had proceeded from a more remote one, that concave glasses benefit the myopic, by producing a contrary effect upon rays which diverge from a distant object, making them fall upon the eye as if they proceeded from a near one." [21]

‡ Aside from the misinterpretation of special optical formulæ, caprice has played a conspicuous part in determining many eccentricities of practice: the business of selling spectacles appears always to have been deeply tainted with quackery.

valid. The common use of cylindrical spectacle lenses dates from the special study of astigmatism by Donders.[27] Quite recently Mr. Borsch, an ingenious practical optician of Philadelphia, has undertaken the manufacture of

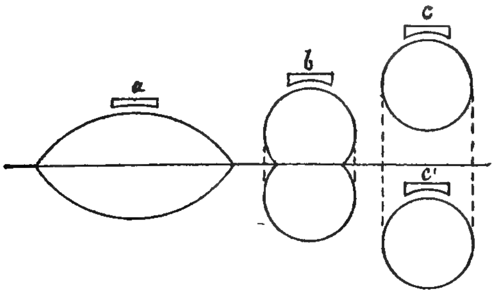

FIG. 3563.

spectacle lenses with a convex or concave surface of unequal radius of curvature in its several meridians, thus combining in one surface the effect usually obtained by the combination of a cylindrical with a spherical surface.[28] The curved surface of such a convex lens represents a small area cut out from a large surface of revolution corresponding to the rounded rim of a wheel; the concave surfaces produced by this method are such as may be worked upon a grinding tool having the form of such a wheel. * Prismatic glasses, first suggested to Donders by his colleague, Krecke, as a possible means of re-establishing binocular vision when it has been lost through the deviation of the visual axes in strabismus, were made the subject of special study by Donders,[30] and have since held a place among the recognized means of dealing with conditions referable to disorders of the external muscular apparatus of the eye. The decentration of ordinary convex or concave lenses, in order to give to the combination of the two spectacle glasses some measure of prismatic effect, was also discussed by Donders.[31] Decentrated convex lenses had already been used in the dissecting spectacles of Brücke,[32] and in the refracting stereoscope of Brewster.[33] Stenopæic spectacles—from στενός, narrow, and ὀπή, a peep-hole—were also introduced by Donders,[34] chiefly for the purpose of admitting to the eye such rays only as correspond to a selected limited area of the cornea or crystalline. Like the so-called *panoptic* spectacles of Serre d'Uzès,[35] they are essentially the same thing as the very old but long disused strabismus goggles (*Schielbrillen — lonchettes*). The snow-goggles of the Esquimaux, which cover the entire front of the eyeball, with the exception of a narrow horizontal slit, are also properly to be regarded as stenopæic spectacles, although designed merely as protectives against the injurious effects of strong sunlight reflected from the snow.

The several forms which have been or may be given to spectacle lenses are shown, for concave and convex lenses respectively, in Figures 3564 and 3565. Of the convex lenses (of positive focus), *a* and *g* (Fig. 3564) are menisci, and may be designated as convex-concave and concave-convex, according as the convex or concave surface is turned toward the eye; *b* and *f*, which have one surface plane, may similarly be designated as convex-plane and plane-convex; *c* and *e* are double-convex lenses, with surfaces of unequal radii of curvature; and *d* is double-convex, with surfaces of equal radii. In concave lenses (of negative focus), we recognize the corresponding forms: Fig. 3565, *–a*, concave-convex, and *–g*, convex-concave; *–b*, concave-plane, and *–f*, plane-concave; *–c* and *–e*, double-concave, with surfaces of unequal radii of curvature, and *–d*, double-concave, with surfaces of equal radii. Of these forms, the two shown in Fig. 3564, *g* (positive meniscus, with the concave surface turned toward the eye), and in Fig. 3565, *–a* (negative concave-convex), are especially designated as periscopic (from περί and σκοπέω) glasses; they offer a

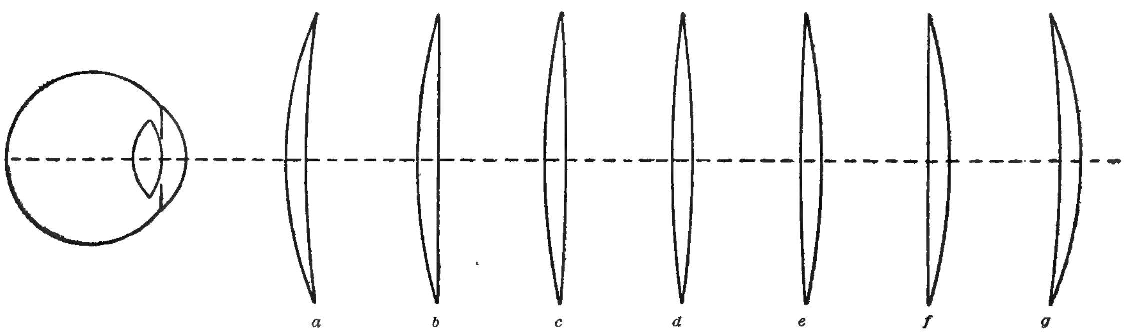

FIG. 3564.

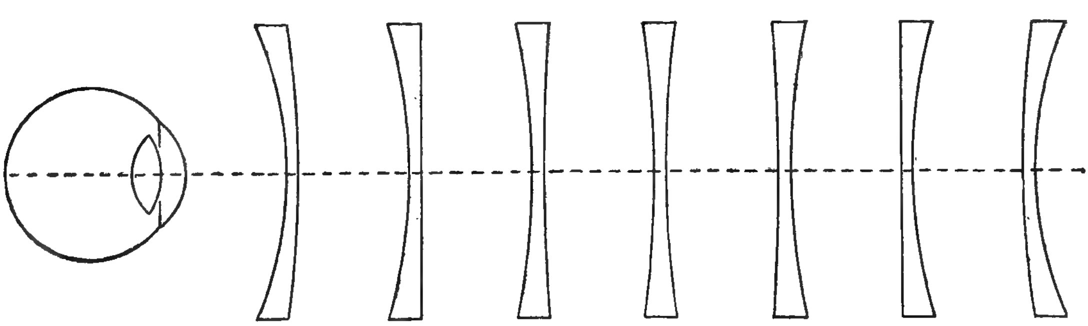

FIG. 3565.

* The entire surface of revolution, as shown in section, takes one of the three forms, Fig. 3563, *a*, *b*, *c*, the last of which is an open ring; the interior surface of such a ring gives a surface (*c′*) convex in one principal meridian and concave in the other, and applicable, therefore, to the correction of mixed astigmatism.[29]

slight advantage when the eyes are so turned as to look obliquely through the right or left half of both glasses. These several forms of lenses, other than the plano-

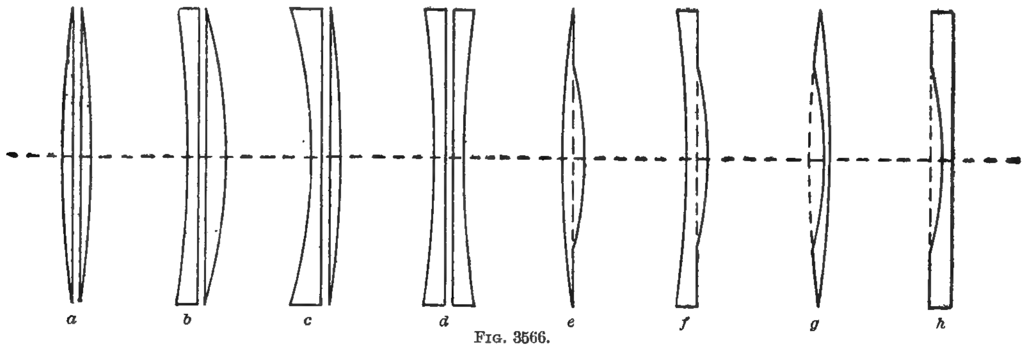

FIG. 3566.

spherical, may all be resolved into combinations of two lenses, each with a spherical and a plane surface, placed with their plane surfaces in contact (Fig. 3566; *a*, *b*, *c*, *d*). Inasmuch as a smaller effective area than that bounded by the usual setting is quite sufficient for most of the uses for which spectacles are worn, it is possible greatly

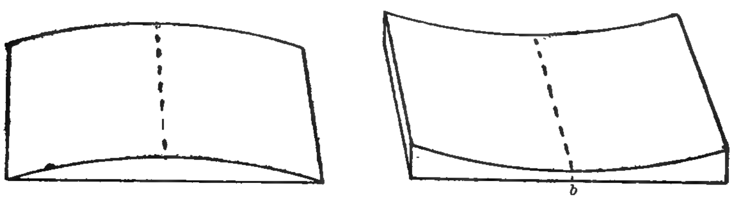

FIG. 3567.

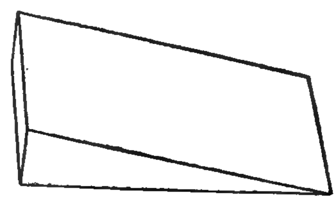

FIG. 3568.

to reduce the weight of the glasses, when required to be of very short focus, by the adoption of forms like those shown in Fig. 3566, *e*, *f*, *g* and *h*.

Cylindrical lenses are found in trade of two forms,

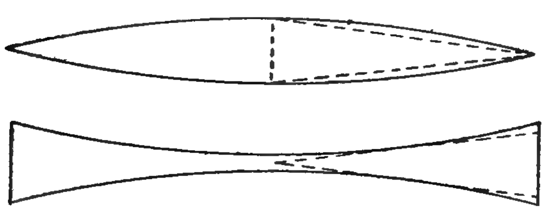

FIG. 3569.

namely, plano-convex and plano-concave (Fig. 3567, *a* and *b*); the dotted line represents the axis of the cylindrical surfaces, which is parallel to the axis of the cylinder of which the lens-surface is a segment. Any required spherical surface, convex or concave, is ground to order by the optician, upon the plane surface of any convex or concave, plano-cylindrical lens. The focal length of a plano-cylindrical lens varies, in its several meridians, from infinity, in the meridian corresponding to the axis, to a least focal length (positive or negative) in the meridian at right angles to the axis. In a spherico-cylindrical lens, with both surfaces of the same kind, *i.e.*, convex or concave, the meridian corre-

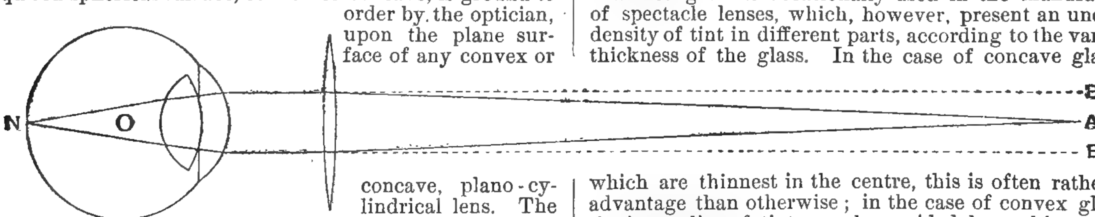

FIG. 3570.

sponding to the axis is that of greatest, and that at right angles to the axis is that of the least (positive or negative), focal length. Cylindrical lenses are sometimes made to order with two cylindrical surfaces of unequal radii of curvature and with crossed axes, but the same optical effect can always be produced with greater ease, and at less cost, by a combination of a single cylindrical (convex or concave) surface with a spherical (convex or concave) surface.*

Prismatic glasses, with plane surfaces, are of the form shown in Fig. 3568; any desired curvature, whether spherical or cylindrical, may be given to either surface, or to both surfaces, of the prism. A prismatic lens with one surface, or both surfaces, ground to a spherical curvature, is equivalent to a lens cut out from a peripheral zone of a spherical lens of greater diameter, as shown in Fig. 3569. A moderate degree of prismatic effect may, therefore, be obtained by the simple expedient of decentering an ordinary spectacle glass; such effects are, in fact, often produced without design, and not infrequently with injurious results, from carelessness in mounting spectacle glasses.

The stenopæic effect may be embodied in any lens, by simply painting over some part of its surface, next the eye, with an opaque, lustreless, black varnish. A partial opacity of the cornea, or a portion of its surface presenting an abnormal curvature, whether original or acquired, may be thus excluded from participation in the formation of the retinal image, with the effect, in some cases, of materially improving the definition of the object.[37]

Tinted glass is occasionally used in the manufacture of spectacle lenses, which, however, present an unequal density of tint in different parts, according to the varying thickness of the glass. In the case of concave glasses, which are thinnest in the centre, this is often rather an advantage than otherwise; in the case of convex glasses the inequality of tint may be avoided by making use of a plano-convex lens to the plane surface of which a thin plate of tinted glass is cemented by means of Canada

* Cylindrical lenses with two cylindrical surfaces, with axes at some other than a right angle, are sometimes prescribed. Such lenses, as well as bi-cylindrical lenses with crossed axes, can always be represented by an optically equivalent combination of a spherical with a cylindrical surface.[36]

balsam. A more elaborate device consists in the cementing of a thin plate of tinted glass between the plane surfaces of two plano-convex (or plano-concave) lenses. Amber has been used as a material for spectacle lenses, notably at Königsberg, about the end of the seventeenth century; the transparency of the amber is said to have been increased by the careful application of heat in a bath of oil or sand.[38]

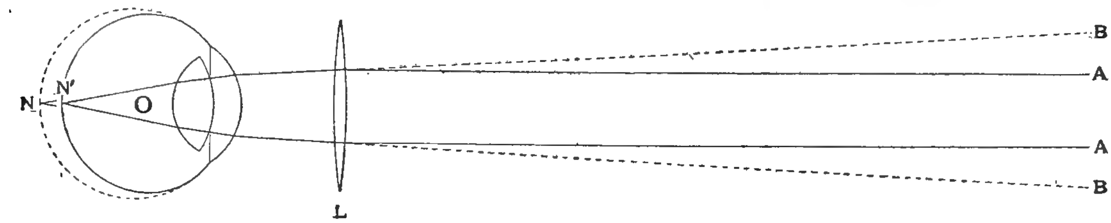

Fig. 3571.

Tinted glasses with parallel surfaces are in common use to temper the light which reaches the eye; they are made either with plane surfaces, like window-glass, or with curved surfaces, like a watch-glass (coquilles). Green was formerly a favorite color, probably from its assimilating the light passing through it to the color of grass and the foliage of trees; blue (the color of the sky) gradually superseded green, and is still much used. A neutral tint, known by the name of London-smoke, has latterly come into common use, and is, in many cases, to be preferred to blue. Glasses of an amber color are also to be found in the shops, generally ground to a dull surface, with the exception of a small, central area.

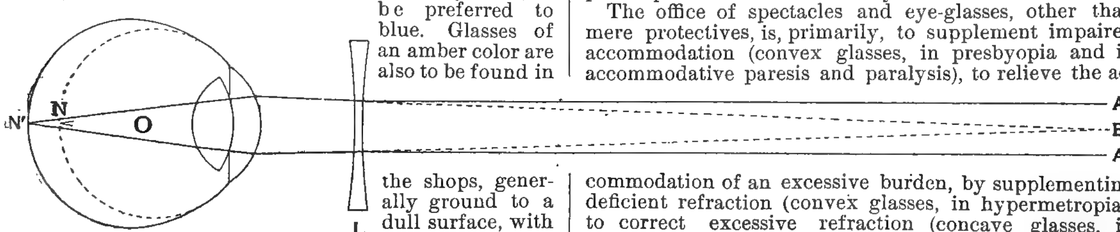

Fig. 3572.

Amber-colored and, still more perfectly, red glasses, by excluding all but the least refrangible rays of the spectrum, may serve (in a strong light) to improve the definition of the retinal image in very low grades of myopia; blue reading glasses, on the other hand, may render some slight degree of aid in low grades of hypermetropia and of presbyopia.[39] Tinted glasses should, as a rule, be mounted in large, oval settings, so as to cover the entire front of the orbit; the coquille form of glass affords more perfect protection than a glass with plane surfaces. Darkly tinted (London-smoke) coquilles are of great use to persons who are exposed to very strong light reflected from sand or from snow, or from the surface of water. Inasmuch as such regularly reflected light is always highly polarized, protective spectacles fitted with thin slices of tourmaline should render valuable service by cutting off the polarized rays, while permitting the unpolarized light, by which objects are actually seen, to pass comparatively unobstructed.[40] London-smoke glass, of so dark a color as to appear quite black in ordinary light, is used in the protective spectacles worn by workmen employed about electric-arc lights, and spectacle glasses made up of several layers of glass of different colors have been found especially useful in observing the intensely brilliant scintillations attending the conversion of pig-iron into steel by the Bessemer process.

All spectacles afford some degree of protection against mechanical injury, and in certain trades it is only by the use of special protectives that the liability to grave accidents to the eyes can be averted. Millers have long been in the habit of wearing large spectacles fitted with thick window-glass when employed in the dangerous work of dressing millstones. Protective spectacles of mica[41] (Cohn, 1868) are especially to be recommended for miners, quarrymen, stone-cutters, boiler-makers, and others engaged in similar dangerous employments. Goggles of finely woven wire-gauze, generally with the fronts glazed with tinted plane glass, are used by railway travellers and others as a protection against flying sparks; goggles made of glass bent to a cylindrical curve of about six inches radius, and furnished with cloth-covered rims to fit closely around the margins of the orbits, are sometimes used as a protection against dust in driving.

Coquille spectacles and eye-glasses, both colorless and tinted, are made also in the meniscus form (with positive focus) and in the concave-convex form (with negative focus); as kept in the shops, they range from about + 8. dioptrics (+ $\frac{1}{5}$) to − 8. dioptrics (− $\frac{1}{5}$). Owing to the shorter radius of curvature of the (concave) surface turned toward the eye, these glasses are more perfectly periscopic than those commonly sold under that name.

The office of spectacles and eye-glasses, other than mere protectives, is, primarily, to supplement impaired accommodation (convex glasses, in presbyopia and in accommodative paresis and paralysis), to relieve the accommodation of an excessive burden, by supplementing deficient refraction (convex glasses, in hypermetropia), to correct excessive refraction (concave glasses, in myopia), and to correct asymmetrical refraction (convex or concave cylindrical glasses, in astigmatism). These several effects are, moreover, often variously combined, as in the use of strong convex glasses, in reading (by hypermetropes with defective accommodation), of partially correcting concave glasses, or, perhaps, of weak convex glasses, in reading (by myopes with defective accommodation), and of glasses of asymmetrical refraction (in compound and mixed astigmatism, and in presbyopia or other accommodative defect occurring in connection with astigmatism).

The action of a convex glass, as used by a presbyope, in reading, is shown in Fig. 3570. Rays emanating from a printed page at A, at such distance from the eye O that the retinal image of the print shall be of sufficient size to admit of its being easily deciphered, are refracted in passing through the lens L (whose focal length must be not less than the distance L A), and are rendered either less divergent—as if they had originated from some point more distant than A—or parallel—as if coming from an

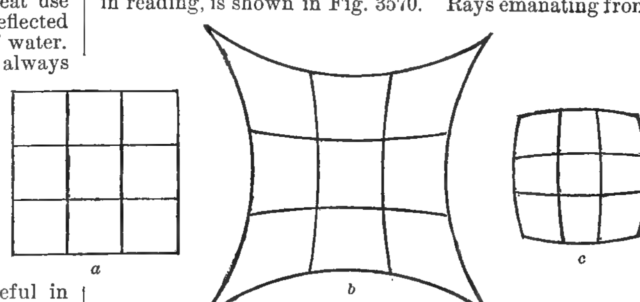

Fig. 3573.

infinite distance. When the focal length of the lens L is equal to the distance L A, the pencils entering the eye

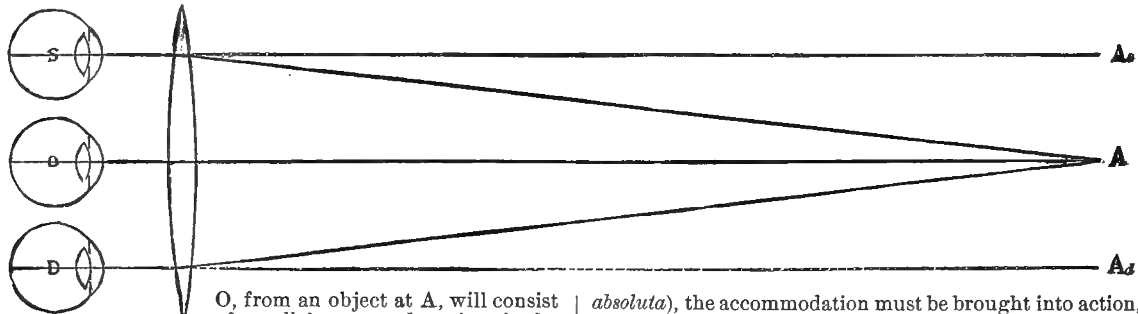

Fig. 3574. L

O, from an object at A, will consist of parallel rays, and a sharply defined retinal image will be formed at N, without exercise of the accommodation. If the focal length of the lens L is greater than the distance L A, the rays forming the several pencils emanating from the object at A will, after refraction by the lens L, be rendered less divergent, as if coming from an object at some distance greater than L A, and the eye O will then be enabled to focus such pencils through the exercise of less accommodation than would

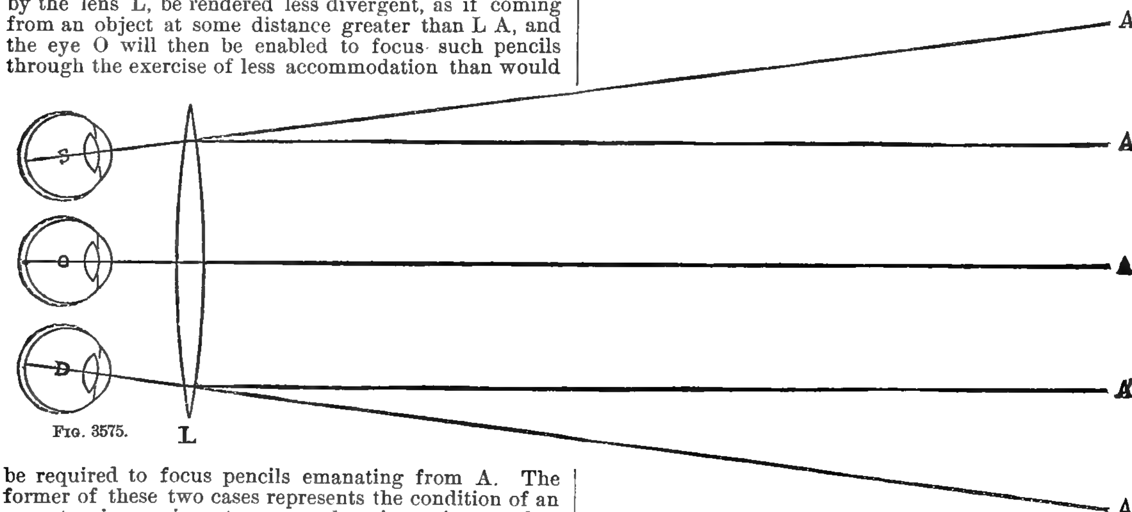

Fig. 3575. L

be required to focus pencils emanating from A. The former of these two cases represents the condition of an emmetropic eye in extreme presbyopia, or in complete paralysis of accommodation; the second case is that of an emmetropic eye in lesser grades of presbyopia, or in a state of weakened accommodation.

The presbyopic eye, when thus adjusted by the convex lens L for the reading distance L A, is, by the very action of the lens, thrown out of adjustment for distinct vision at a distance; a presbyope wearing glasses for

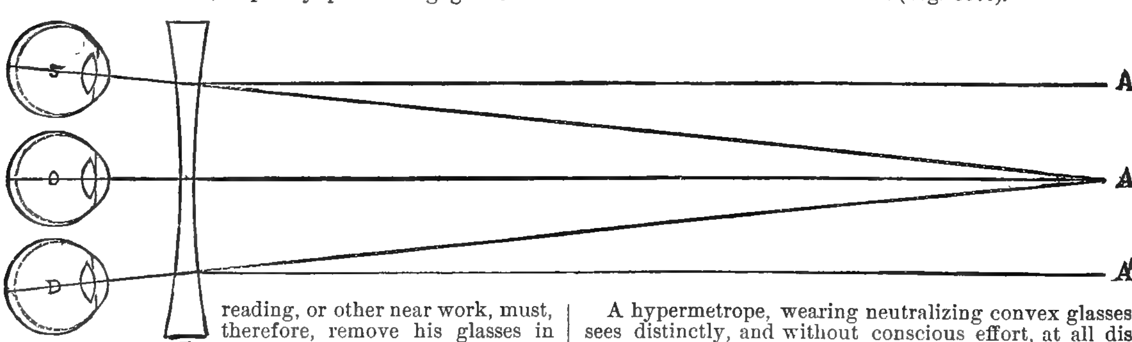

Fig. 3576. L

reading, or other near work, must, therefore, remove his glasses in order to see distinctly at a distance.

Fig. 3571 shows the effect, in distant vision, of a neutralizing convex glass in hypermetropia. A pencil of parallel rays A A, emanating from a distant object, is focussed by an emmetropic eye, without exercise of the accommodation, upon its retina at N. In order to focus the same pencil upon the retina of the hypermetropic eye, at N′ (in all grades of hypermetropia less than H *absoluta*), the accommodation must be brought into action, either wholly or in part.* The neutralizing convex lens L converts the parallel rays of the pencil into rays of such degree of convergence that the hypermetropic eye O can focus them accurately at N′ without using any part of its accommodation; the entire accommodation is thus rendered available to meet the requirements of near vision, and the hypermetropic eye, with its neutralizing glass, becomes virtually emmetropic.

In the extreme case of total presbyopia, or of complete paralysis of accommodation in the hypermetropic eye, a lens equal in power to the sum of the two lenses L (Fig. 3570) and L (Fig. 3571) will be required for distinct vision at the distance L A (Fig. 3570).

A hypermetrope, wearing neutralizing convex glasses, sees distinctly, and without conscious effort, at all distances; when, however, he becomes also presbyopic, the neutralizing convex glasses cease to afford sufficient help in reading, and stronger glasses become necessary. These stronger reading glasses are, however, too strong

* In absolute hypermetropia the total accommodation is insufficient to focus parallel rays.

for distinct vision at a distance; hence, an elderly hypermetrope requires, as a rule, two pairs of convex glasses, the one, neutralizing, for distinct vision at a distance, and another pair, of shorter focus, for reading.

Fig. 3572 shows the use of a neutralizing concave glass, in distant vision, in myopia. The pencil of parallel rays, A A, emanating from a distant object, is focussed by the myopic, as by the emmetropic, eye at the normal position of the retina at N; the actual position of the retina, in the myopic eye, is, however, farther back, as at N'. The myopic eye, in a state of complete accommodative relaxation, can focus only divergent rays, as from an object at some short distance L B, upon its retina, and, by the exercise of its accommodation, can also focus rays diverging from some still nearer point, somewhat within the distance of nearest distinct vision (P) for an emmetropic eye. The neutralizing concave lens L converts the parallel rays of the pencil A A into rays of such degree of divergence as they would have if emanating from B, and thus the myopic eye O is enabled to focus them upon its retina at N'. The farthest point of distinct vision (r) is thus carried off, by the neutralizing concave glass, to an infinite distance, and the near-point (p) is removed to about the distance of the near-point in emmetropia.

When the myopic eye becomes restricted in its range of accommodation, as a result of advancing age, the neutralizing concave glasses must either be laid aside in reading or exchanged for concave glasses of greater focal length (*i.e.*, weaker concave glasses); in myopia of a low grade, it may even become necessary, in reading, to make use of convex glasses, but weaker than those which would be required by an emmetrope of the same age.

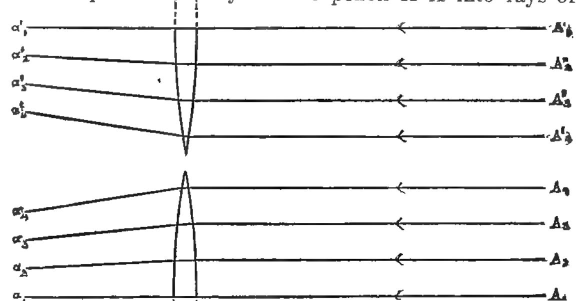

FIG. 3577.

A myope wearing neutralizing concave glasses, like the hypermetrope wearing neutralizing convex glasses, sees distinctly at all distances. Only when he becomes presbyopic does he find himself compelled either to lay aside his concave glasses, in reading, or to exchange them, temporarily, for weaker concave, or, possibly, for weak convex glasses.

Comparing Figs. 3571 and 3572, it will be seen that the pencil of parallel rays A A (Fig. 3571) is of notably greater diameter than the pupil, and, conversely, that the pencil A A (Fig. 3572) is of less diameter than the pupil. As the areas of the cross-sections of the two pencils are to each other as the squares of their diameters, it follows that there must be a very considerable gain in the brightness of the retinal image in the case of hypermetropia corrected by convex glasses, and a corresponding loss of illumination in the case of myopia corrected by concave glasses. These two conditions are, in fact, essentially the same as in looking through an opera-glass in the proper direction and in the reversed direction. Hypermetropes, wearing convex glasses, see somewhat better than emmetropes, by moonlight or starlight, and myopes, wearing concave glasses, see less perfectly under the same conditions; in the higher grades of myopia the disability from this cause is sometimes so great as to simulate night-blindness (see Hemeralopia).

Objects viewed through convex glasses appear larger than do the same objects when their images are focussed by the exercise of the accommodation, and, conversely, objects viewed through concave glasses under accommodative tension appear smaller than do the same objects when viewed without exercise of the accommodation. Hence, a presbyope, using convex glasses in reading, sees the print not only clearer than without glasses, but also larger than it appears to an emmetrope under normal exercise of the accommodation. So, also, a hypermetrope, wearing convex glasses, sees all objects larger than when he views them without glasses, and a myope using concave glasses in reading sees the print smaller than when he reads without glasses. In (axial) hypermetropia, however, the actual size of the retinal image is smaller, as in (axial) myopia it is larger, than in emmetropia; and it is a fact now well established that both hypermetropes and myopes wearing neutralizing glasses at the usual distance from the eye see objects of about the same apparent dimensions as does an emmetrope without glasses.

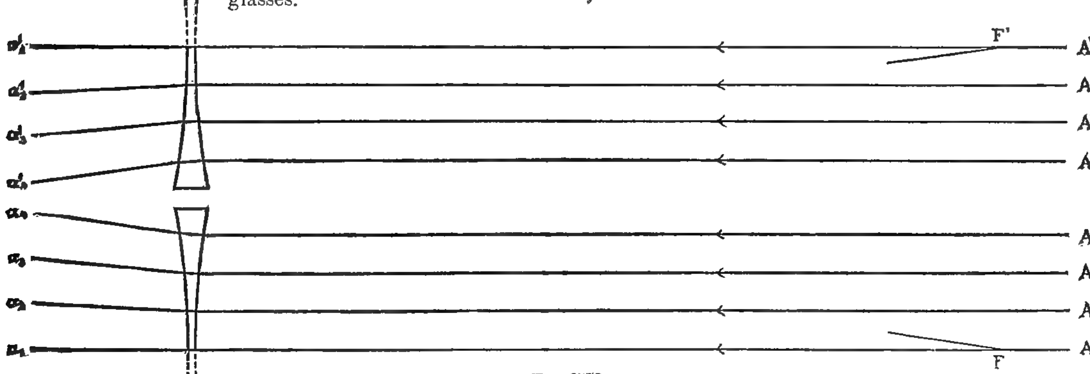

FIG. 3578.

A convex spectacle lens is increased in effective power by increasing its distance from the eye, and, conversely, a concave lens loses in effective power with any increase in its distance. The correct rule of practice is to mount the glasses as near as possible to the eyes, allowing sufficient room for the free play of the eyelashes. A distance of thirteen millimetres from the vertex of the cornea fulfils this condition in most cases, and at the same time allows the correcting lens to be placed almost exactly at the anterior principal focus of the eye, in which position of the glass the retinal image, whether in hypermetropia or in myopia, becomes practically equal in size to the image of the same object when focussed by an emmetropic eye. Whenever a hypermetrope inclines to remove his (convex) glasses to a greater distance from the eye than thirteen millimetres it may be assumed that the glasses are


FIG. 3579. [43]

somewhat too weak fully to correct his hypermetropia, and, conversely, when a myope inclines to wear his (concave) glasses at a distance greater than thirteen millimetres from the eye it may be assumed that the glasses are somewhat too strong. This particular mode of correcting the effect of badly selected glasses in distant vision is but rarely adopted, except in the presence of defective accommodation, as, for instance, by elderly hypermetropes or myopes, and especially by persons who have undergone an operation for cataract. In presbyopia it is a not uncommon practice to slip the (convex) reading glasses far down toward the tip of the nose, in order to make a weak glass do the office of a stronger glass in improving the distinctness of the print, and also in increasing its apparent size; in this position of the glasses it is also easy to look over them at distant objects.

The increase or diminution in the apparent size of objects viewed through a convex or concave lens is not uniform in all parts of the visual field, but is notably greater at its periphery than at its centre. Thus, a large object viewed, centrally, through a spherical convex lens is seen more highly magnified in its peripheral than in its central portions; a square, for example, whose angles are more distant from the centre than is the middle of each side, is seen as if bounded by curved lines with their convexity turned toward the centre of the field.


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FIG. 3580.

The same square, when viewed through a concave lens, is seen diminished in size, but most diminished in its peripheral portions, so that it appears as if bounded by curved lines with their concavity turned toward the centre. Fig. 3573 shows at *b* and *c* the distortion under which a large square figure *a*—a window, for example—is seen through a convex and a concave lens, respectively; it will be observed that the distortion of the smaller squares increases from the centre toward the periphery of the field.

It has been often remarked that myopes, in selecting concave glasses, are very apt to err by making choice of glasses of somewhat too short focus, which cause objects seen through them to appear very sharply outlined. This phenomenon appears to be a result of the chromatic aberration of the eye, causing the object, when viewed through a concave glass under a full correction for the most highly refrangible (violet) rays of the spectrum, to be seen as if bounded by a very narrow red border, instead of by a broader violet fringe, as when the eye is focussed for the least refrangible (red) rays. If a distant point of light is viewed by an over-corrected myopic eye through a piece of cobalt-blue glass, the light will appear blue, with a narrow red halo; if the eye is under-corrected by its concave glass, the light will appear red, with a broader violet halo.

A convex or concave cylindrical lens, as used for the correction of astigmatism, simply elongates or shortens the retinal image in a direction at right angles to the axis of the lens; thus, the relation of the two diameters of the object appears altered, a circle appearing elongated or shortened to an ellipse, etc. The distortion from this cause in regular astigmatism, when the direction of the two principal meridians happens to be asymmetrical in the two eyes, may give rise to such difference in the two retinal images as to evoke a great variety of stereoscopical illusions from the fusion of the two impressions in binocular vision; illusions of this kind are, however, very soon corrected by experience, as the wearer of the cylindrical glasses becomes accustomed to the new conditions.

Incidental to the action of convex and concave glasses in modifying the exercise of the accommodation is the effect which they exert upon convergence as associated with accommodation. Convex glasses, by relieving the accommodation of a part of its load (in hypermetropia), exert at the same time a positive effect in diminishing the correlated convergence; hence, they rank first among the therapeutic agents at our disposal for arresting the development of convergent strabismus, and even, in many cases, for its cure. Concave glasses, on the other hand, by increasing the demand made upon the accommodation

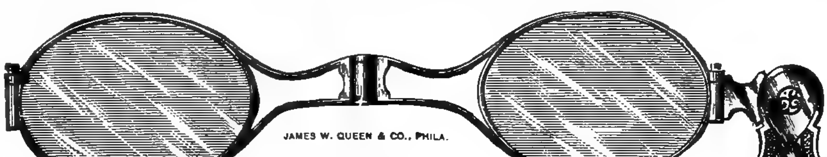


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FIG. 3581.

in near vision (in myopia), evoke also increased action of the recti-interni muscles, with correlated relaxation of the recti-externi, and thus afford relief in many cases of muscular asthenopia and of crossed diplopia, and even of divergent strabismus.

Spectacles, whether convex or concave, may be so mounted as to exert also a direct action upon convergence. This effect may be developed accidentally, as a result of imperfect centration of one or both glasses, and may then be attended with more or less harmful consequences, or it may be produced designedly, and applied with advantage to the treatment of muscular insufficiency.

This action of convex and concave glasses is shown, for three particular cases, in Figs. 3574 to 3576. The large convex lens L (Fig. 3574) receives divergent rays from the point A, situated at a distance equal to its principal focal length, which rays are rendered parallel by the lens. An emmetropic eye at O, behind the centre of the lens, sees an object at A by looking directly at it, in the direction O A; but an eye at D, or at S, in order to see the same object, must look in the direction D Ad, or S As, parallel to O A.

In Fig. 3575 the large convex lens L receives the parallel rays of the pencil A′ A_1, coming from a distant object, and renders them convergent. A hypermetropic eye at O, behind the centre of the lens, sees the object lying in the direction O A, by looking directly at it; but an eye at D, or at S, in order to see the same (very distant) object, must look, not in its true direction, D A′, or S A_1, but in the direction D Ad, or S Aa.

In Fig. 3576 the large concave lens L receives the par-

allel rays of the pencil A′ A_1, coming from a distant object, and renders them divergent. A myopic eye at O, behind the centre of the lens, sees the distant object lying in the direction O A, by looking directly at it; but an eye at D, or at S, in order to see the same (very distant) object, must look, not in its true direction, D A′, or S A_1, but in the direction D A, or S A.

If we take D and S as representing the right and left eye, the effect of the lens, in the three cases under consideration, will be (1) to associate parallelism of the visual axes with full relaxation of the accommodation in looking at a near object (in emmetropia, Fig. 3574); (2) to compel divergence of the visual axes (or else to evoke homonymous diplopia, in looking at a distant object (in hypermetropia, Fig. 3575); or (3) to compel convergence of the visual axes (or else to evoke crossed diplopia) in looking at a distant object (in myopia, Fig. 3576). In all three cases the conditions thus evoked are unnatural, and the second and third involve a divorcement of the allied adjustments of accommodation and convergence. The arrangement shown in Fig. 3574 is that employed in so-called cosmoramas, or peep-shows, to produce the double illusion of increased size and greater distance in looking at a photograph or other picture through a large convex lens. In the arrangement shown in Fig. 3575 single vision with the two eyes is impossible, except in the abnormal condition of divergent strabismus, which, however, is only exceptionally found associated with hypermetropia. In the arrangement shown in Fig. 3576 the excessive convergence incidental to looking through the marginal portions of the concave lens tends to evoke some measure of accommodation also, and thus to impair the distinctness of distant vision when the lens is of such focal length as exactly to correct the myopia.

The proposal to make use of decentrated lenses, as shown in Figs. 3574 and 3576, in uncomplicated presbyopia and myopia,[42] is irrational. In presbyopia complicated with marked falling off in the acuteness of vision, the principle illustrated in Fig. 3574 may be utilized to relieve the recti-interni muscles of undue strain in reading, at exceptionally short range, with convex glasses of very short focal length. The dissecting spectacles of Brücke[32] are constructed on this principle.

The action of decentrated lenses, when the centre of each lens is removed to the temporal instead of to the nasal side of the eye, is shown, for convex and concave lenses respectively, in Figs. 3577 and 3578. In Fig. 3577 the two halves of a convex lens, divided through its centre, are transposed, so that the right eye looks through what was originally the left half of the lens, and the left eye through the right half. The parallel rays A_1, A_2, A_3, A_4, and A'_4, A'_3, A'_2, A'_1, of the two pencils, after traversing the two halves of the lens, become convergent, with foci at F and F′. By varying the distance between the two lenses, the symmetrically refracted rays A_1 A'_1, A_2 A'_2, A_3 A'_3, or A_4 A'_4 may be made to fall opposite the centres of the pupils of the two eyes, which will then be compelled to assume positions varying from parallelism of the visual axes to a considerable degree of convergence.* In the case of the transposed halves of

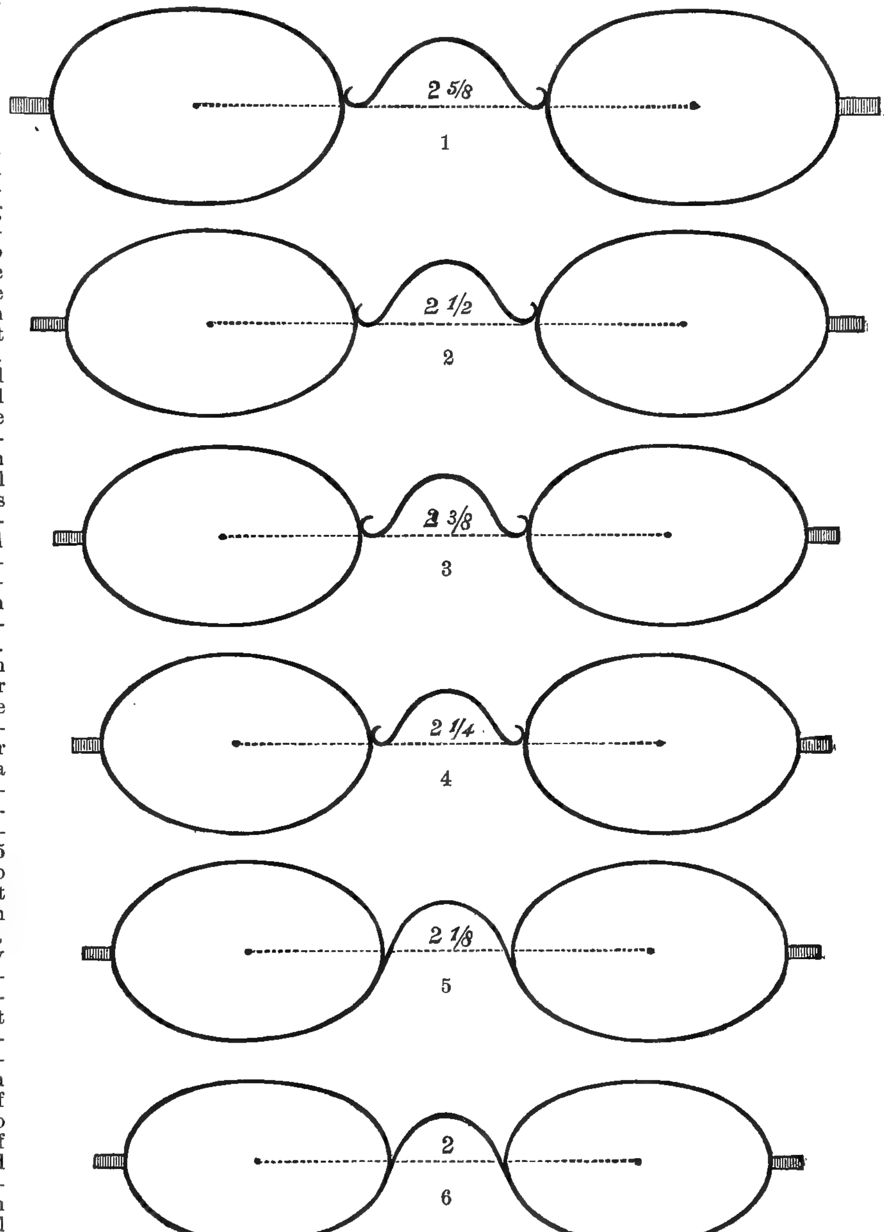


FIG. 3582.[44]

* The arrangement of transposed halves of a convex lens, as shown in Fig. 3577, is that usually adopted, after Brewster,[33] in the construction

a concave lens (Fig. 3578) the conditions are exactly the reverse of those shown in Fig. 3577.

Instead of cutting out two spectacle lenses from a peripheral zone of a very large convex or concave lens, it is found to be quite as convenient, and much less costly, to grind the required convex or concave surface upon one side of a prism; upon the other side of the prism a cylindrical surface may be ground if required for the correction of astigmatism. Such glasses are of not infrequent use in ametropia, when complicated by insufficiency of the recti-interni or of the recti-externi muscles, and are thus available in many cases of muscular asthenopia, and of diplopia of moderate grade even when dependent on paresis of one of the recti muscles; in strabismus, they are seldom of much utility.

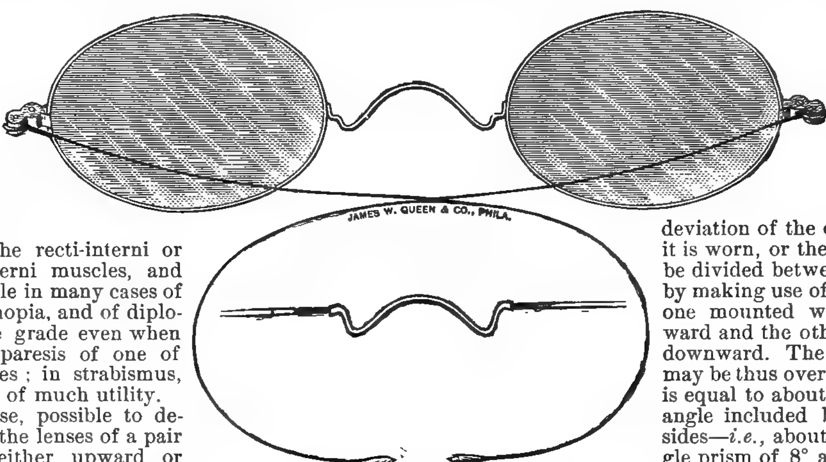


FIG. 3583.

It is, of course, possible to decentrate one of the lenses of a pair of spectacles, either upward or downward, or to decentrate one glass upward and the other downward; this expedient is occasionally utilized in cases of slight upward or downward deviation of one of the visual axes.

The decentration of a spherical lens, whether convex or concave, necessarily gives rise to some distortion of the retinal image, and the greater the decentration the more pronounced will be the distortion. This is shown in Fig. 3573, *b*, and *c*, in which the small squares at the sides and at the angles of the larger square are drawn as they are seen through peripheral portions of a convex or a concave lens. Moreover, the several pencils of rays, after refraction by a decentrated lens, are no longer homocentric, *i.e.*, they no longer converge toward or diverge from a focal point, but pass through two so-called focal lines. In other words, a decentrated spherical lens always gives rise to some degree of astigmatism, which may, in certain cases, be so great as to require correction; this may be effected by using lenses of the plano-convex or plano-concave form, and grinding a cylindrical surface upon the plane side.*

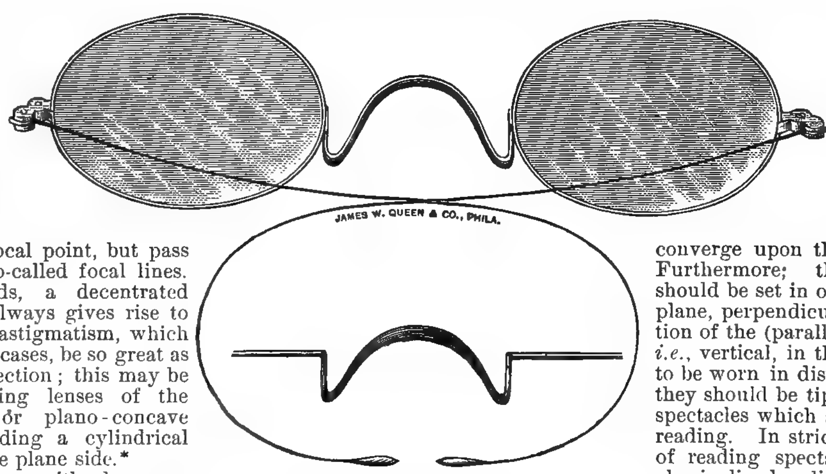


FIG. 3584.

Prismatic glasses with plane surfaces (Fig. 3568) may be mounted with their bases turned toward the nose, in which case they relieve the recti-interni muscles of a part of their work in convergence, and may also restore binocular vision at a distance in cases of crossed diplopia, dependent on very slight divergence of the visual axes. Mounted with their bases turned toward the temples, they are applicable in certain cases of insufficiency of the recti-externi, or of preponderance of the recti-interni, as in the homonymous diplopia which is sometimes observed in low grades of convergent strabismus. A prismatic glass, mounted with the base upward or downward, before one eye only, may be used to neutralize the effect of a slight upward or downward deviation of the eye before which it is worn, or the correction may be divided between the two eyes by making use of two prisms, the one mounted with its base upward and the other with its base downward. The deviation which may be thus overcome by a prism is equal to about one-half of the angle included between its two sides—*i.e.*, about 4° with a single prism of 8° angle, or 8° with a prism of 8° angle worn before each eye. Prisms of more than 8° angle are ordinarily rejected on account of the conspicuous colored fringes due to chromatic dispersion.

The normal effect of any spectacle lens is, as already shown, obtained only when the lens is accurately centred in front of the pupil; another important condition is that the plane in which the lens is set be perpendicular to the direction of the visual axis. The distance between the centres of the two lenses of a pair of spectacles intended to be worn in distant vision should, therefore, be exactly equal to the interpupillary distance, but in the case of reading glasses, the distance between the centres of the two lenses should be somewhat less than the lesser inter-pupillary distance when the visual axes are made to converge upon the printed page. Furthermore, the two lenses should be set in one and the same plane, perpendicular to the direction of the (parallel) visual axes—*i.e.*, vertical, in the case of glasses to be worn in distant vision—but they should be tipped forward in spectacles which are to be used in reading. In strictness, the lenses of reading spectacles should be also inclined a little toward each other, so as to face the point of intersection of the visual axes upon the printed page.

Whenever a (convex or concave) spherical lens is set obliquely to the direction of the visual axis, its refractive power is increased, though in very different degree, in all its meridians, the increase being greatest in the meridian corresponding to the plane of the arc through which the lens is rotated, and least in the meridian of the axis about which the rotation takes place. In the case of a (convex or concave) cylindrical lens, rotated about its axis, the increase in refractive power varies from a maximum, in the meridian at right angles to the axis, to zero, in the meridian of the axis. When rotated about the

of stereoscopes; its effect is to permit the two (slightly different) pictures, mounted upon the stereoscopic slide, to be viewed, at one and the same time, by the two eyes, under moderate convergence of the visual axes, or, as is more commonly the case, to permit two pictures whose corresponding points are more widely separated than are the centres of the two pupils to be viewed by the two eyes with parallel visual axes.

* For a mathematical discussion of these and other examples of the effects of spherical aberration, the reader is referred to special works on optics—*e.g.*, Parkinson's Optics, Chapter IV., "on focal lines of small oblique pencils, and caustics;" also Chapter VII., "on spherical aberration of lenses."

meridian at right angles to its axis, a (convex or concave) cylindrical lens shows also a positive increase in refractive power, though in a lesser degree than when it is

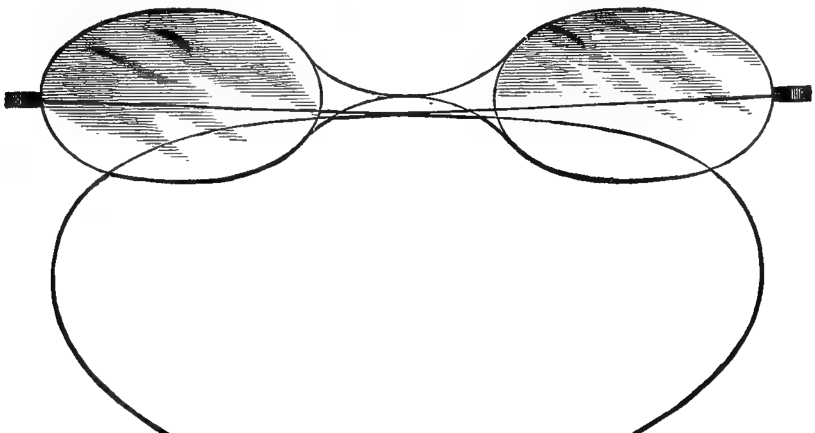


FIG. 3585. [44]

rotated about its axis. It follows that a tipped spherical lens becomes practically equivalent to a (somewhat stronger) spherical lens with a cylindrical lens added to it, and that, in the case of a spherico-cylindrical lens, the special effect of the cylindrical surface may be either increased or diminished, according as the (compound) lens is rotated about one or the other of its principal meridians. A tipped concave spherical lens may be occasionally utilized, in distant vision, in myopia, with astigmatism of relatively low grade, when the ocular meridian of greatest refraction happens to be vertical (or very nearly vertical), and a vertically mounted convex spherical lens may be given, for reading, when the ocular meridian of greatest refraction happens to be (exactly or approximately) horizontal.* Again, in myopia with astigmatism, when the ocular meridian of greatest refraction happens to be approximately horizontal, the wearer of concave spherical glasses may learn the trick of looking obliquely through his glasses, either to the right or to the left, and may thus add materially to his acuteness of vision, though at the cost of acquiring an awkward carriage of the head. So, also, a hypermetrope with some measure of astigmatism, when the ocular meridian of greatest refraction happens to be approximately vertical, may, similarly, get a better correction from his (convex spherical) glasses by looking obliquely through them to one side.

A myope, wearing concave glasses of a power insufficient fully to correct his myopia, is very apt to look obliquely to one side, in order to improve his vision for the vertical lines of a distant object, and he may, at the same time, contract the opening of the eyelids, in order to improve his vision for horizontal lines. In hypermetropia, this habit is but rarely acquired, for the reason that here the accommodation is generally brought into exercise to supplement the effect of the glasses, but in aphakia, owing to the total loss of accommodative power, it is not infrequently observed.

Spectacle lenses are usually mounted in oval rings of metal (rims—*cercles*), or, in the case of eye-glasses, of tortoise-shell, horn, hard rubber, celluloid, etc. The rims used in mounting convex glasses are almost always grooved, so as to grasp the sharp edge of the lens; concave glasses, too, are ground, as a rule, to a sharp edge, and mounted in grooved rims, but it is a not infrequent practice to groove

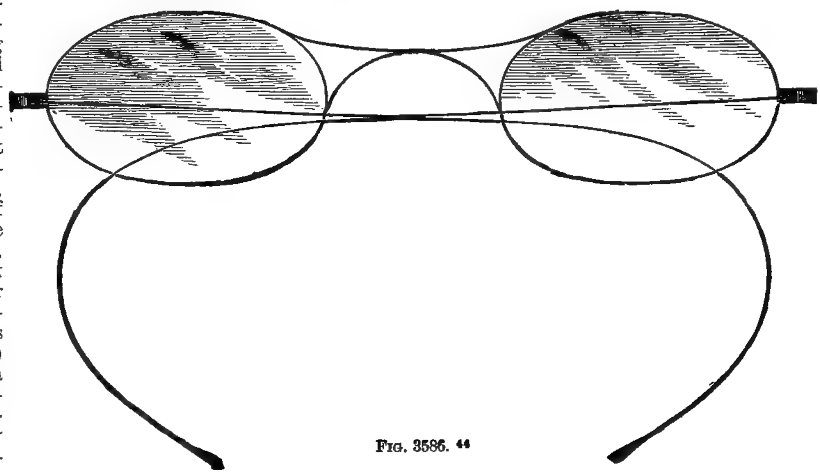


FIG. 3586. [44]

the lens itself, and to sink the rim, which is then made of thin (steel or gold) wire, in the groove. Convex lenses, also, are occasionally mounted with the rims sunken, but at the cost of making the lens needlessly thick and heavy. So-called frameless or rimless glasses have the nose and side pieces attached by means of screws passing through holes drilled in the lenses at their nasal and temporal sides; concave lenses, with their thick margins, lend themselves better to this construction than do convex lenses.

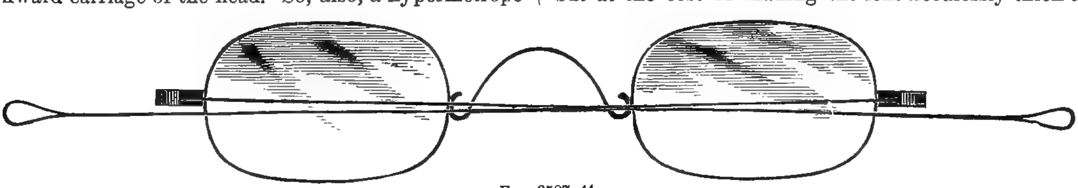


FIG. 3587. [44]

Caprice has sometimes dictated the wearing of a single eye-glass, carried at the end of a riding-whip, a fan, etc., or worn suspended by a cord; in the latter case the glass is held in front of the eye by contracting the orbicularis

* A familiar instance of such a correction, in myopia, is seen in the not infrequent preference given to a tipped (concave spherical) eye-glass over glasses mounted in a vertical position, in a spectacle frame. So, also, after an operation for cataract, a spherico-cylindrical lens, with axis horizontal, may be required to raise distant vision to its maximum, although, for reading, a spherical glass may be preferred, by reason of the augmented refraction, in the vertical meridian, incident to the oblique (downward) direction of the visual axes.

muscle upon its rim in a singularly awkward and inconvenient fashion. Binocular glasses may be divided, ac-

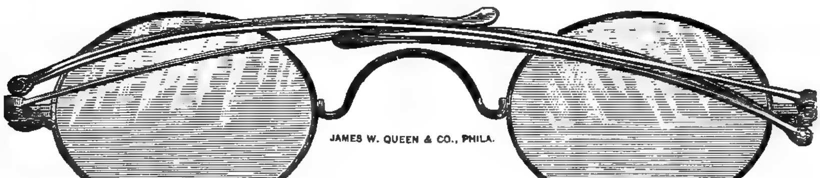


FIG. 3588.

cording to the way in which they are held before the eyes, into three groups—namely, eye-glasses held in the hand (lorgnette—*face à main*; Figs. 3579, 3580, and 3581 [43]), those held in place by means of a spring which pinches the nose (*pince-nez—Nasenzwicker, Nasenklemmer*), and spectacles proper, which are held in place by means of side-pieces passing above and behind the ears (*lunettes à branches*). To these three principal types may be added a fourth, now disused except in the case of protective goggles, in which the glasses are held in place by means of tapes or an elastic band passing around the head above the ears.

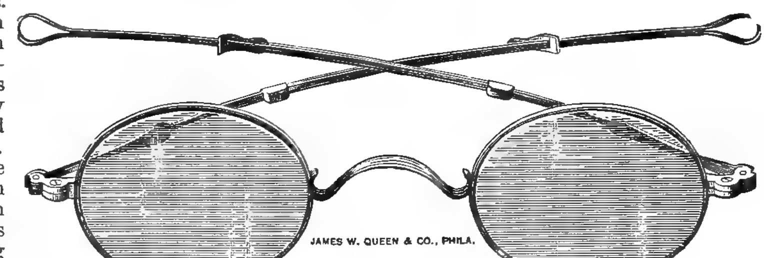


FIG. 3589.

The several parts of a pair of spectacles are (1) the rims (*cercles*), in which the glasses are mounted, (2) the bridge, or nose-piece (*arcade centrale*), by which the rims are connected and supported upon the

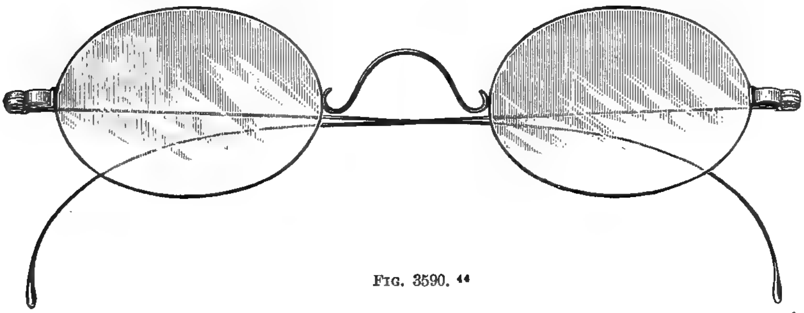


FIG. 3590. [44]

bridge of the nose, and (3) the side-pieces (temples—*branches laterales*), by which the spectacles are held in place upon the head. The size of the rims and the length of the bridge should be so proportioned as to conform both to the interpupillary distance, in order that the wearer may look through the centres of the glasses, and to the width of the face, so that the side-pieces may touch, but not press too tightly against, the sides of the head. In the case of great width of face, larger rims are generally required than when the face is narrow (see Fig. 3582 [44]); any variation from the usual proportion between the interpupillary distance and the width of the face may generally be met by varying the length of the bridge. In order properly to fit the face, it may sometimes be necessary to select a frame in which the distance between the centres of the rims is a little

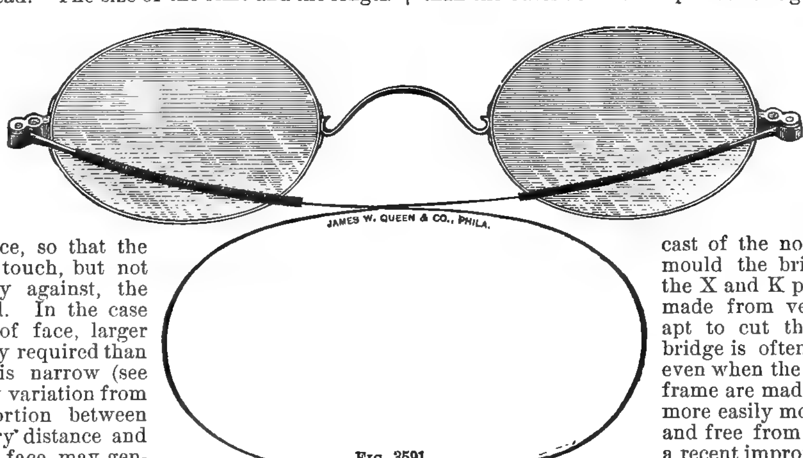


FIG. 3591.

greater or a little less than the interpupillary distance, but in such a case care should be taken, in setting the glasses, to preserve the proper distance between their centres.

The bridge should be shaped to fit the nose, and partially to encircle it; noses, however, differ very greatly in prominence and in thickness, so that no single type of bridge is suited to all cases. The "hoop" bridge (Fig. 3582, 5 and 6) is one of the older forms, and is suited to noses of considerable thickness and prominence; the hoop may lie in the same plane with the glasses, or it may be turned forward at any required angle. The slightly modified form shown in Fig. 3582, 1, 2, 3, and 4 is now more commonly used than the plain hoop, and, like it, may be set at any required angle to the plane of the glasses. These forms are well suited to noses of some prominence, but in other cases they fail to support the glasses at the proper height, or at a sufficient distance from the eyes to avoid contact with the eyelashes. To obviate this serious defect in the hoop bridge two very useful modifications have been recently introduced, namely, the twisted or "snake" bridge (Fig. 3583 [43]), and the "saddle" bridge (Fig. 3584 [43]). The so-called X bridge (Fig. 3585 [44]), and the K bridge (Fig. 3586 [44]), are extensively used in frames of very light weight; they are, however, of less general applicability than the other forms. A perfect bridge should present a rather broad surface of contact with the nose, and special care should be taken to secure an accurate and easy fit; in rare instances it may even be worth while to make a cast of the nose upon which to mould the bridge. Bridges of the X and K patterns, as usually made from very thin wire, are apt to cut the nose. A gold bridge is often to be preferred, even when the other parts of the frame are made of steel, as being more easily moulded to the nose and free from liability to rust; a recent improvement consists in the application to the hoop or saddle bridge of a lining of fine cork. Spectacle-frames of tortoise-shell were once in common use, and are on many accounts to be commended; frames are still made

in limited quantities with the rims and bridge formed from a single piece of shell or of celluloid. Either material may be softened by the application of a gentle heat, so that the bridge may be bent to almost any desired shape.

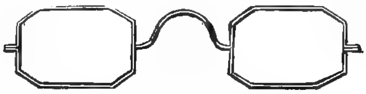


Fig. 3592.[43]

The side-pieces (temples—*branches*) should be slightly bowed to fit the sides of the head; they should be of at least sufficient length to reach a little behind the ears (single temples, Fig. 3587[44]), or they may be made a couple of inches longer by jointing them on a pivot at about the point where they rest upon the ears (turn-pin temples, Fig. 3588[43]), or by the use of a sliding mechanism (sliding temples, Fig. 3589[43]). Best of all are the hooked or "riding" temples (Figs. 3583 to 3586, and 3590[44]), which are made of thin and very elastic wire bent downward in an easy curve behind the ears. By a recent invention, consisting in the introduction of a delicate, spirally wound wire in the side-pieces, near their proximal ends, the flexibility of hooked temples has been materially increased (Fig. 3591[43]).

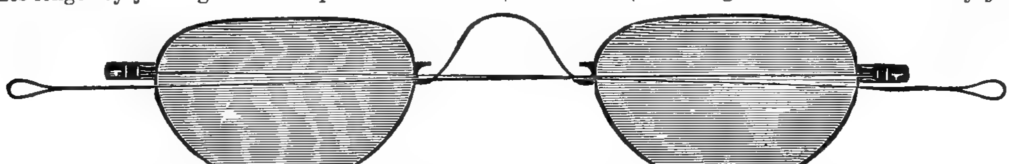


Fig. 3593.[44]

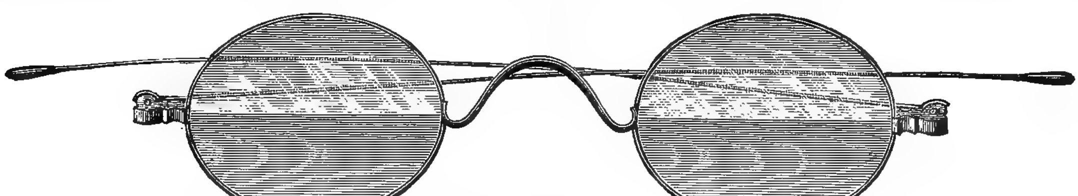


Fig. 3594.[44]

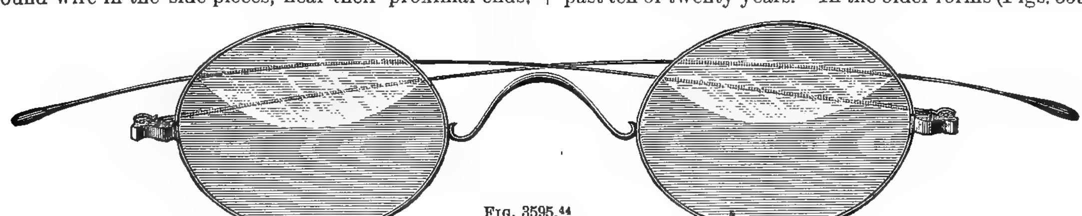


Fig. 3595.[44]

The several parts of a spectacle-frame should be nicely proportioned to each other. In the case of spectacles with single temples the bridge should be of sufficient stiffness to maintain its shape unaffected by the lateral spring of the side-pieces. Only when hooked temples are used is it admissible to make all parts of the frame of very light weight.

Fashion has played its part in prescribing the form of spectacle-glasses; the original shape was doubtless circular, a form still occasionally adopted for spectacles, but more frequently for eye-glasses. The shape now generally preferred is a nearly regular oval, but with considerable variation in the proportion of the two principal diameters. Another and perhaps preferable form is oblong, with rounded angles (Fig. 3587). A parallelogram with the four corners cut off by straight lines (octagon glasses, Fig. 3592[43]) was a favorite shape not many years ago, and, though rather ungraceful, is still occasionally used. Pantoscopic glasses, so called, have the upper part of the rims flattened (Fig. 3593[44]), in order to permit the wearer of reading glasses to see over them in looking at distant objects; the glasses are also set, as a rule, obliquely to the direction of the side-pieces, but perpendicular to the direction of the visual axes in reading. In ametropia, with defective accommodation, it is often convenient to mount two half-lenses in each rim (Fig. 3594[44]), the upper half (convex or concave) of a focal length suited to the correction of the actual hypermetropia or myopia, the lower half, of the focus needed for reading; * a similar effect is obtained, though somewhat less perfectly, by grinding the upper and lower halves of the same lens to different radii of curvature (bi-focal glasses—*verres à double foyer*, Fig. 3595[44]). Another useful arrangement consists in mounting a reading correction in a separate frame, to be hooked upon the front of the spectacles habitually worn in distant vision (Fig. 3596[44]).

Eye-glasses of the *pince-nez* † pattern have been made since an early period in the history of spectacles, but their construction has been greatly improved within the past ten or twenty years. In the older forms (Figs. 3597[44] and 3598[44]) the centres of the glasses stand much too near together, and the glasses themselves are very apt to tip forward in a way that is sometimes very detrimental to the optical effect intended to be obtained from them. In

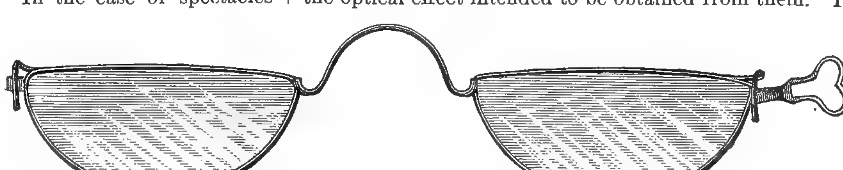


Fig. 3596.[44]

many cases, also, they stand so near to the eyes as to allow insufficient room for the play of the eyelashes, and when-

* Benjamin Franklin is said to have worn such glasses, and they are commonly called by his name.

† In a fresco by Dom°. Ghirlandajo (1449–1494), in the Church of Sta. Trinita at Florence, an elderly bishop is represented as reading through a *pince-nez* set very low upon the nose; the rims of the glasses are circular, and the connecting arc is apparently rigid. This construction and manner of wearing the *pince-nez* explains the objection formerly made to it, as liable to compress the nostrils and impart a nasal quality to the voice. A fac-simile of the portion of the fresco containing this head has been reproduced, in color, in one of the publications of the Arundel Society, London, 1860.

ever the nose is unsymmetrical one glass is pretty sure to stand noticeably higher than the other. In eye-glasses of improved construction these defects are to a considerable extent obviated. Thus most of the modern eye-glasses have some form of projecting nose-clips, which may be set either in the same plane with the glasses, or in a plane behind that of the glasses and inclined to it at any required angle to secure the best possible bearing upon the sides of the nose; some eye-glasses have also a provision for adjusting the clips, upon the two sides, so as to fit noses of almost any shape and thickness, and of very considerable degrees of asymmetry. A cork-lining to the clips greatly increases their adhesiveness, and thus does away with the necessity of strong pressure in order to hold the glasses firmly in position (Figs. 3599 [43], 3600 [43], 3601 [43], and 3603 [43]). The tilting of the glasses, in cases of exceptional prominence of

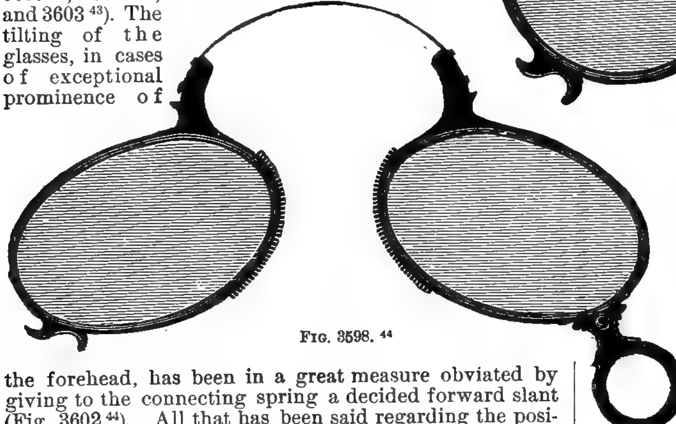


FIG. 3598. [44]

the forehead, has been in a great measure obviated by giving to the connecting spring a decided forward slant (Fig. 3602 [44]). All that has been said regarding the position of the glasses when mounted in spectacle-frames applies equally to eye-glasses, and it is often possible, by taking sufficient pains, to fit up a *pince-nez* which shall prove a very tolerable substitute for a pair of spectacles. For mounting cylindrical and prismatic glasses they are especially unsuitable, by reason of the difficulty which is apt to be experienced in keeping them straight before the two eyes. The especial convenience of eye-glasses lies in the fact that they are easily put on and off; they are not well suited for reading, except for a few minutes at a time, nor for continuous wearing in distant vision. In most cases of asthenopia, and especially in progressive myopia, the wearing of a *pince-nez* should be prohibited.

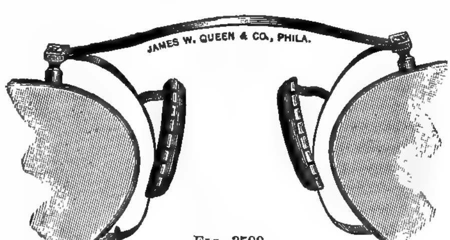


FIG. 3599.

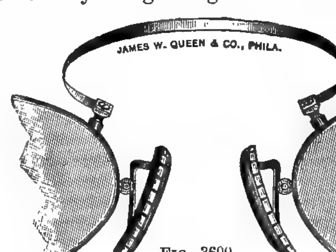


FIG. 3600.

The different methods used in testing eyes for the cor-

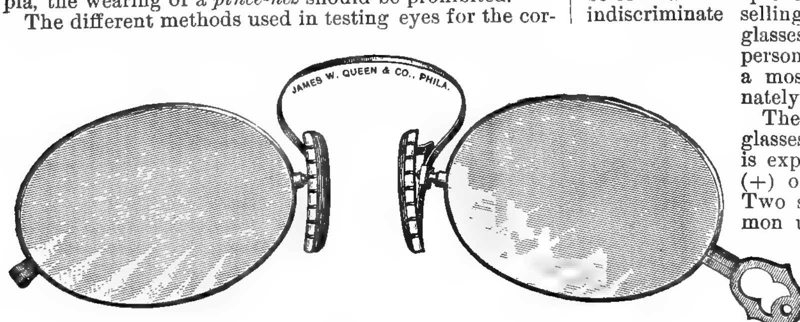


FIG. 3601.

rection of the several refractive and accommodative defects, whether simple or complicated, have been already described under the titles Astigmatism, Hypermetropia, Myopia, Presbyopia, and Optometry. The points to be particularly investigated in all cases are (1) the state of the refraction, (2) the acuteness of vision, and (3) the state of the accommodation. Only after these three determinations have been made, with at

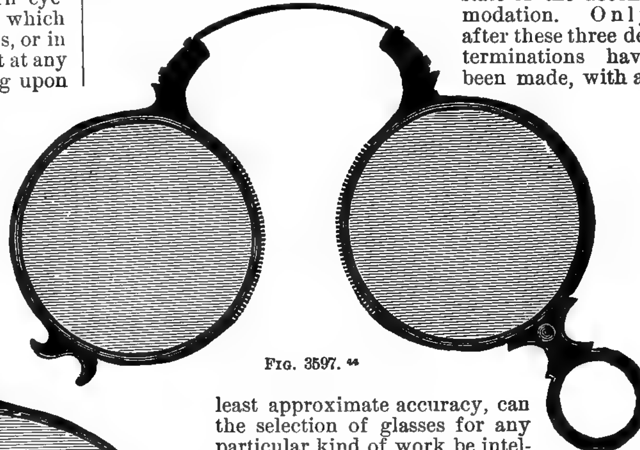


FIG. 3597. [44]

least approximate accuracy, can the selection of glasses for any particular kind of work be intelligently made. In the present state of diffusion of knowledge in the domain of physiological optics these tests can be safely entrusted only to the ophthalmic specialist—physicians and spectacle-dealers being alike incompetent, as a rule, to decide any but the simplest questions. A person who has arrived at the age of forty-five years without having experienced any trouble in the continuous use of his eyes in near and distant work, may not be likely to commit any great error in buying weak convex glasses when he becomes conscious that he is beginning to suffer from the disabilities of presbyopia; but even in such a case an examination of the eyes by a competent observer may bring to light some measure of astigmatism which it may be well worth while to correct, or, possibly, some pathological condition which it may be of vital consequence to detect in its incipiency. The indiscriminate selling of concave spectacles and eye-glasses to young myopes, or to young persons hastily assumed to be myopic, is a most reprehensible, as it is, unfortunately, an almost universal practice.

The power of convex and concave glasses, whether spherical or cylindrical, is expressed by numbers, with the plus (+) or the minus (−) sign prefixed. Two systems of numbering are in common use, the older (inch) system, based on a unit-lens with two curved surfaces of equal radii of 1 Paris inch; the other or new (metric) system, in which a lens of a focal length of 1. metre (dioptric; D) is taken as the unit. In the older system it so happens, through an accidental relation of the Paris to the English inch, that the focal length of a bi-convex or bi-concave lens, of equal radii, in

Spectacles.

English inches is almost exactly equal to the radius of curvature in Paris inches. The two systems may, therefore, be regarded as based respectively upon unit-lenses of 1 English inch and 1. metre focal length. The difference between the two systems consists essentially in the fact that in the case of the smaller unit, of 1. metre focal length, the power of any lens of a power greater than this unit is expressed by a whole number or by a whole number and a decimal fraction, whereas in the case of the larger unit, of 1 English inch focal length, the power of every lens is expressed in the form of a vulgar fraction, with unity for its numerator, and the focal length of the lens, in English inches, for its denominator. Each system has practical advantages of its own, and neither is of such pre-eminent merit as to justify the total rejection of the other. Fortunately, the relation of the metre to the English inch is such as to admit of the use of the two systems interchangeably, by taking the metre-lens (dioptric) as practically equivalent to the lens numbered $\frac{1}{40}$ in the inch system—an assumption which involves an insignificant error, and less than that which arises from the use, at different times and by different makers, of glass whose index of refraction is not always exactly the same. Tables I. and II. give the two series of numbers according to the two systems, as they are generally kept in stock by opticians, and for which grinding tools are ordinarily available.

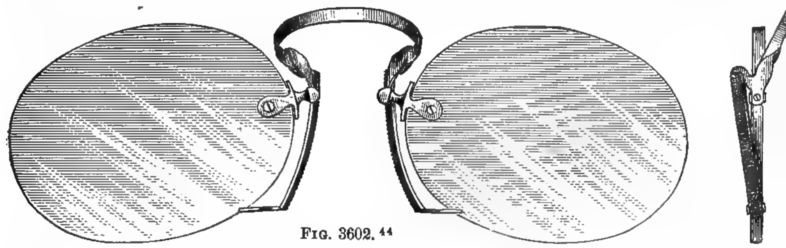


FIG. 3602.[44]

Table I.		Table II.	
Inch System. (Fractional expression.)	Metric Equivalent. (Dioptrics.)	Metric System. (Dioptrics.)	Inch Equivalent. (Fractional expression.)
1–144	0.277	0.25	1–160
1–120	0.333	0.5	1–80
1–96	0.416	0.75	1–53$\frac{1}{3}$
1–84	0.476	1.0	1–40
1–72	0.555	1.25	1–32
1–60	0.666	1.5	1–26$\frac{2}{3}$
1–48	0.833	1.75	1–22$\frac{6}{7}$
1–42	0.952	2.0	1–20
1–36	1.111	2.25	1–17$\frac{7}{9}$
1–30	1.333	2.5	1–16
1–24	1.666	2.75	1–14$\frac{6}{11}$
1–20	2.0	3.0	1–13$\frac{1}{3}$
1–18	2.222	3.5	1–11$\frac{3}{7}$
1–16	2.5	4.0	1–10
1–15	2.666	4.5	1–8$\frac{8}{9}$
1–14	2.857	5.0	1–8
1–13	3.077	5.5	1–7$\frac{3}{11}$
1–12	3.333	6.0	1–6$\frac{2}{3}$
1–11	3.636	7.0	1–5$\frac{5}{7}$
1–10	4.0	8.0	1–5
1–9	4.444	9.0	1–4$\frac{4}{9}$
1–8	5.0	10.0	1–4
1–7	5.714	11.0	1–3$\frac{7}{11}$
1–6$\frac{1}{2}$	6.154	12.0	1–3$\frac{1}{3}$
1–6	6.666	13.0	1–3$\frac{1}{13}$
1–5$\frac{1}{2}$	7.272	14.0	1–2$\frac{6}{7}$
1–5	8.0	15.0	1–2$\frac{2}{3}$
1–4$\frac{1}{2}$	8.888	16.0	1–2$\frac{1}{2}$
1–4	10.0	18.0	1–2$\frac{2}{9}$
1–3$\frac{1}{2}$	11.428	20.0	1–2
1–3$\frac{1}{4}$	12.307	....	....
1–3	13.333	....	....
1–2$\frac{3}{4}$	14.545	....	....
1–2$\frac{1}{2}$	16.0	....	....
1–2$\frac{1}{4}$	17.777	....	....
1–2	20.0	....	....

Cylindrical lenses are numbered according to their power (in dioptrics) or focal length (in English inches) in the meridian at right angles to the axis. Lenses of unequal refraction in their two principal meridians are almost always made by grinding a spherical and a cylindrical surface upon the two sides of the same glass, and the formula for such a lens is written, for each surface, exactly as if the lens were made up of a plano-spherical and a plano-cylindrical lens with their plane surfaces in contact. The direction of the axis of a cylindrical lens or surface is defined by giving its inclination (in degrees of arc) to either the horizontal or the vertical plane of the eyeball. If the two surfaces of any lens, where they are cut by the axis of the eye, are not parallel, the deviation from parallelism is expressed by the magnitude of the angle which the two tangent-planes make to each other, as if the two refracting surfaces were ground upon the two surfaces of a prism; the direction of the refracting angle of this prism is defined in the same manner as the direction of the axis of a cylindrical lens.

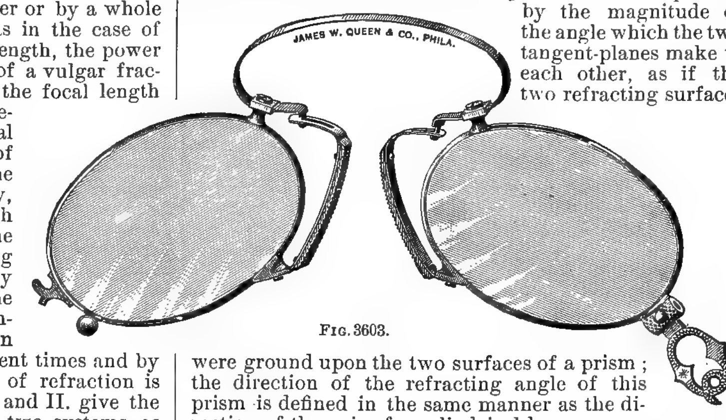
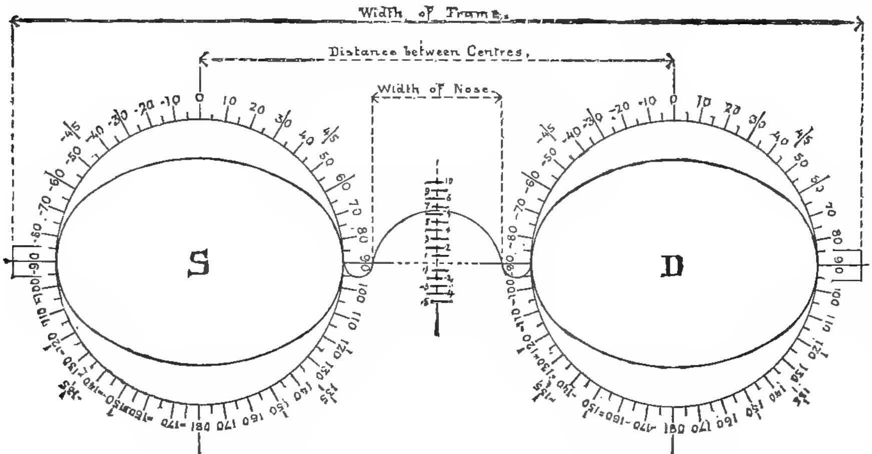


FIG. 3603.

In prescribing spectacles it is convenient and useful to lay off these angles on a printed diagram. Such diagrams have been in common use in this country since 1876, and are furnished, in a variety of forms, by most opticians. A spectacle frame (Fig. 3604) is shown in the position in which the wearer is supposed to look through it, and the angles are marked, in degrees, with the plus (+) sign to the right, and the minus (−) sign to the left of zero, which is taken at the upper end of the vertical meridian. A more usual, but less natural, system of marking the angle of inclination is by beginning with zero on the horizontal line, at the left side, and numbering around the upper half of the circle to 180°. A half-circle is sufficient to designate the direction of the axis of any cylindrical lens, but the whole circle of 360° is required to indicate the different directions in which it may be necessary to turn the refracting edge of a prismatic glass.

The power of any (convex or concave) lens is most easily measured by placing over it an equivalent (concave or convex) lens, of known value, and looking through the two lenses at a straight line, such as a sash-bar of the window; the equivalence of the two lenses is shown by the absence of any enlargement or diminution of the virtual image, as indicated by the immobility of the image of the (vertical) bar when the mutually neutralizing glasses are moved from side to side. In applying this test to a cylindrical lens the axis of the lens must be so turned as to coincide in direction with the line used as a test-object; in the case of a spherico-cylindrical lens the refraction may be measured in the two principal meridians in succession, the lesser of the two measurements representing the spherical, and their difference representing the cylindrical refraction when both surfaces are of the same kind (*i.e.*, convex or concave). The direction of the two principal meridians of a cylindrical or spherico-cylindrical lens is readily determined by holding the lens in a plane perpendicular to the axis of the

eye, and looking, through its centre, at the sash-bar; the lens is then rotated, in its own plane, until the direction of the image coincides exactly with the direction of



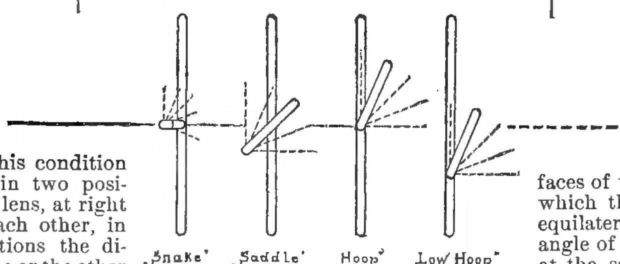


FIG. 3604.

the bar. This condition is fulfilled in two positions of the lens, at right angles to each other, in which positions the direction of one or the other principal meridian coincides with the direction of the bar. The middle point of any spherical or spherico-cylindrical lens is readily found by noting the point at which the crossing of two sash-bars coincides in the image and in the object.

John Green.

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[43] From the trade catalogue of James W. Queen & Co. Sixty-fifth edition, Philadelphia, 1886.
[44] From the trade catalogue of Meyrowitz Brothers. Second edition, New York, 1885.

SPECTROSCOPY, MEDICAL. The spectroscope is an instrument for examining the *spectrum*. A *spectrum* is, primarily, the series of colors produced when a ray of white light is transmitted through any transparent body, the surfaces of which are not parallel. The general form which this transparent body takes is that of an equilateral *prism* of glass, the sides forming an angle of sixty degrees. Hollow prisms with sides at the same angle are also used, being filled with transparent liquids.

Sir Isaac Newton first made the observation that when a ray of white light is transmitted through a prism the ray is not only bent out of its course, but is spread into an array of colors, the order of which is nearly invariable, no matter what the source of light or the material of which the prism is composed. Since the facility of differentiating colors varies in different persons, the exact tints of the spectrum so formed are not easy to express, but they are generally assumed to be seven in number, and arranged as follows: violet, indigo, blue, green, yellow, orange, red. If the ray of light be, as in Newton's original experiment, admitted through an opening of appreciable dimensions, the colors will be somewhat confused and will appear unbroken, but when the opening is very narrow a more distinct effect is produced, and, as will be seen below, the spectrum is crossed by numerous dark lines. It is a law of the propagation of light that when a ray passes from one transparent substance to another of different density it undergoes a deflection, known technically as *refraction*. The direction and extent of this refraction depend on the nature of the materials and on the difference of the densities. When the ray passes from a rarer to a denser substance, for instance, from air to water, or from water to glass, the ray is bent (refracted) so as to be more nearly parallel to a line perpendicular to the surface of contact, while if the ray passes in the reverse direction, that is, from a denser to a rarer body, as from glass to water, the refraction is away from the perpendicular. It is upon this principle that the image-forming and magnifying properties of all lenses depend.

The accepted theories in regard to light refer it to very rapid vibration, and the difference between the various colors is supposed to be due to difference in the rate of vibration. White light is supposed to contain all the rates of vibration, and when such a ray undergoes refraction the different vibrations are refracted to different degrees, and hence are separated. If we view a ray through a plate of glass or other transparent body with parallel sides, the refraction produced in one direction on

entering the glass is corrected by the refraction in the opposite direction on emerging, so that, with the exception of a slight displacement of the line of light, no striking optical change is manifest. If, however, the equilateral prism is used, the refraction on emergence is in the same direction as on entering, and the optical action is exaggerated. The separation of the different vibrations that compose a ray of white light is called *dispersion*, and is not coextensive with refraction, that is, bodies of equal refractive power do not necessarily separate the colors to the same extent. This law is a very important one in practical optics, for all lenses are forms with more or less prismatic outlines, and hence produce a dispersive effect. If it were only possible to prevent production of color by neutralizing the refraction, it would be impossible to construct any convenient optical apparatus free from colored images, but by combining different varieties of glass in such forms as to have equal and opposite dispersive powers with difference of refraction, large lenses entirely free from color defects (achromatic) may be constructed.

In the spectroscope the object is to secure as complete and extended a dispersion as possible; that is, to separate the colors thoroughly. For these purposes prisms of dense glass, or hollow prisms filled with carbon disulphide, CS_2, are used.

The simplest method of examining the spectrum is to allow a ray of light to enter a dark room or dark box through a small opening and fall upon a prism. Upon the side of the room opposite the opening will be seen a more or less confused spectrum, in which all the colors will be found diverted from the path which the original ray would pursue if it did not enter the prism, the violet being most diverted and the red the least. Such a method of observation, however, is unsuitable for scientific purposes. The most serious defect in it is that if the ray has an appreciable thickness the vibrations on one part interfere and overlap those of the other, so that the series of colors obtained is really a combination of a number of spectra not coincident with each other. To obtain a pure spectrum the ray must be reduced to an exceedingly fine line of light, in which there will be but few sets of vibrations. This is accomplished by using a very narrow slit, and shutting off all light from the prism except that which passes through this slit. The observation is also much facilitated by viewing the spectrum through a telescope of low magnifying power.

About the beginning of this century Dr. Wollaston, an English chemist, discovered, by using such a slit, that the spectrum of sunlight is not continuous, but is interrupted by numerous fine, dark lines. He did not develop this observation, and it was not until 1814 that Fraunhofer, a German optician, rediscovered these lines and mapped the positions of a considerable number of them. Some of the most prominent he distinguished by letters of the alphabet. They have in consequence generally been known as the Fraunhofer lines. They are all at right angles to the direction of the spectrum, and their distance from each other depends on the dispersive power of the prism. Since each particular line is always seen in the same color, and is more easy to define than the limits of the color itself, these lines are preferred for purposes of comparison.

Various improvements and advances in the construction of apparatus for observing spectra have been made from time to time, until the spectroscope in its usual form consists essentially as follows: A straight tube terminates at one end by a narrow, upright, adjustable slit, and at the other a convex lens, the focal length of which is the distance between it and the slit, so that the rays of light as they pass through the latter are rendered parallel by the lens. In the course of these rays is placed a dense glass prism, or series of prisms, greater dispersion being attained by a combination of prisms. A movable telescope of low magnifying power, arranged so that it can be brought in the course of the rays emerging from the prism, enables one to view conveniently the spectrum formed. Such an arrangement constitutes a *refraction spectroscope*. In the cut there is shown a third tube, illuminated by a candle. This contains a graduated scale, an image of which is projected in the field of view above the spectrum, for the purpose of measurement, as given below.

Another form of the instrument depends on a somewhat different principle, and as it is now in frequent use and possesses advantages over the older form it will be necessary to describe it.

When the surface of a polished flat plate is ruled with a considerable number of fine lines in very close proximity, on viewing the plate obliquely, series of spectra are seen which are due to interferences in the different light waves as they are reflected from the angular surfaces produced by the ruling. This effect is called *diffraction*, and a plate so arranged is called a *diffraction grating*. The superiority of such an instrument rests principally on the fact that in all parts of the spectra the colors are proportionately distributed. In the ordinary spectrum, as seen by the prism, the dispersion is proportionately greater toward the violet end, and consequently this portion is abnormally spread out and the distances between the dark lines are exaggerated.

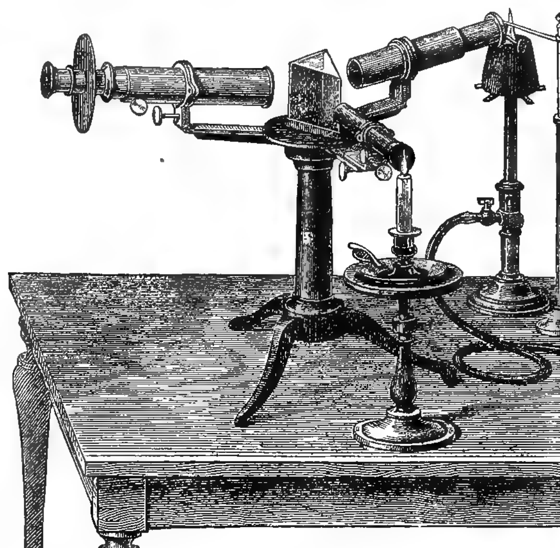

FIG. 3605.

Spectra, by whatever method observed, may be divided into three groups:

1. Continuous spectra: Those in which a more or less continuous sheet of color is seen, usually beginning with violet and ending with red. Such spectra are produced by the light which is emitted from solid objects in a highly heated state.

2. Interrupted, or bright-line spectra: Those in which the colors are seen in the form of narrow lines or bands, separated by proportionately wide, dark spaces. Such spectra are derived from light emitted by gaseous bodies in a highly heated condition.

3. Absorption spectra: Those in which a nearly continuous series of colors is present, but interrupted by dark lines or bands. Such spectra are produced by various conditions, principally, however, by the transmission of white light, or light which would give a continuous spectrum, through substances which have the power of absorbing or annihilating special vibrations. In the applications of the spectroscope to medicine and organic chemistry these absorption spectra are the most important.

It is obvious from the above considerations that we have in the spectroscope, whether of the refraction or diffraction form, a very valuable means of studying structure. In the first place, we can determine with great exactness the character of the source of light, *i.e.*, whether it is composed of gaseous matter intensely heated or of solid particles. Further, taking a source of known

character, we can, by interposing various substances in the path of the light, determine the effect which those substances produce upon the different forms of light vibrations present in the ray, and as particular effects are often peculiar to particular bodies, we have here a means of identification. Thirdly, using a source of heat practically non-luminous, such as the flame of the Bunsen burner, we can detect different substances by the color they impart to this flame, and when several such substances are present the eye alone is unable to separate and distinguish the colors, but by the spectroscope each tint is distinctly indicated

As stated above, it is the absorption spectra that are most important in reference to the medical applications of the spectroscope. Except in the comparatively rare cases of the study of the character of light emitted by luminous organic bodies, living or dead, and in the detection of certain metals present in minute amount in the tissues and secretions, *e.g.*, lithium, the direct study of normal spectra is not much resorted to in biological work.

The arrangement of the spectroscope for observation of absorption spectra is simple. An oil- or gas-flame is adjusted so as to throw a beam of light through the slit of the instrument, by which a continuous spectrum not broken at any point by dark lines is obtained. Sunlight does not answer so well for the purpose, because, owing to certain interfering conditions occurring at the surface of the sun, and also during the passage of the sunlight through our atmosphere, there are numerous absorption bands (Fraunhofer's lines) always present in its spectrum. The material to be examined is placed in a cell with flat sides in the path of the light before it enters the slit. It is scarcely necessary to observe that to secure a satisfactory result the body must be sufficiently transparent to permit some light to pass through, otherwise no comparison as to the effect on different parts of the spectrum can be made. Such a condition is easily obtained by using solutions of the substance in the usual colorless solvents—water, alcohol, ether, glycerine, etc., and diluting until a satisfactory result is obtained. The character of the absorption spectra sometimes differs, according to the solvent used and the presence of free acid or alkali. Working spectroscopes are generally arranged so that two spectra can be compared, one being a standard obtained under known conditions, the other being that of the body to be tested.

To understand the functions of the spectroscope it is necessary to bear in mind that the colors seen are practically images of the slit through which the light passes, and that when the ray contains all the colors, that is, every vibration from violet to red, the prism, in setting out the vibrations according to dispersive-power, gives, of course, a continuous series of images, that is to say, a continuous spectrum. When, however, in the ray of light that enters the slit any vibrations are missing, as in sunlight, or when by some interposed condition certain colors are struck out of the ray, the images which would otherwise be formed by those rays are missing, and hence the spectrum appears interrupted. When the interposed substance strikes out many rays, *e.g.*, deep-colored glasses, the great bulk of the spectrum is missing. The red glasses, for instance, used in photographic dark-rooms strike out all rays but the red. The spectroscope as ordinarily constructed is, unfortunately, subject to serious defects, which can be avoided only by instruments of very expensive form. It has been found that all the forms of glass possess marked absorption powers for certain rays of light. If, instead of employing glass lenses and prisms, we use those made of quartz, and employ as a source of light the electric arc, or burning magnesium wire, a spectrum is obtained which is very much extended at the violet end. This portion of the spectrum exists to a greater or less extent in white light from any source, but is absorbed to such an extent by glass that it is not seen in the ordinary spectroscope. There are also color waves beyond the red, which are only demonstrable by special apparatus. In the usual applications of the spectroscope we cannot, therefore, utilize the so-called ultra-red and ultra-violet rays.

A very important advance has been made recently in practical spectroscopy in the application of photography. A sensitive plate is capable of responding to and recording conditions which the eye is unable to recognize, and we have, therefore, not only a method of extending our knowledge of spectra, but we may obtain permanent records of absolute accuracy, and independent of any general or special defects in vision. This method is yet incompletely developed, but it promises well. The photographic plate is especially capable of receiving impressions from the violet and ultra-violet portions of the spectrum, which are especially those which the eye appreciates with the greatest difficulty, while the yellow and red rays are practically inactive.

Many substances are known which have the power to retard the rate of vibration of light rays, so that they change the color of the light falling on them. Now, the ultra-violet rays, which are inappreciable to the human eye, are caused by extremely rapid vibrations; any substance which will reduce this rate will bring the rays within the range of vision. This property is known as fluorescence. It does not come within the scope of this article to more than refer to it, but it may be mentioned that one of the most recent advances in the preparation of photographic plates is to incorporate into the sensitive material some fluorescent body by which the rays of light are modified and effects produced with colors that would otherwise be inactive. It is not unlikely that we have in this method a line for still further extension of the application of photography to the spectroscope

The only way of acquiring familiarity with spectroscopic appearances is by actual use of the instrument. No drawing, colored or otherwise, can convey perfectly the appearances. Nevertheless, a method of indicating the character and position of the lines is useful, and several plans have been adopted. The use of colored plates is, of course, the most vivid, but too costly for most purposes. The usual methods are either by recording the position of any line, or the centre of a band, by its position on an arbitrary and fixed scale, or by angular position. A form of spectroscope made by Browning, of London, has this latter arrangement. The view telescope moves in a graduated arc, and cross lines in the field enable it to be brought to exact position with any line. By such method or by the scale the lines may be mapped in their relative positions as seen in that particular instrument.

Another method is to indicate the positions of lines by their calculated wave-lengths; that is, the length of one complete movement constituting the ray which produces a line at the given point. Such a method has the advantage of being an absolute indication, and not dependent on any particular instrument. Wave-lengths are determined by mathematical calculation by means of the phenomena observed in diffraction, and the calculation may be easily applied to ordinary cases by plotting off on a chart certain lines of which the wave-lengths are known, and interpolating those of which it is desired to determine the wave-length. These lengths are very minute, and are usually expressed in millionths of a millimetre.

Description of Special Spectra. *Bright-line Spectra.*—Each of the known elements gives a special and distinct spectrum when heated sufficiently to become a luminous gas. It has been pointed out at the beginning of the article that solid substances give continuous spectra, and hence there is no appreciable difference between the spectroscopic appearances of the different elements as long as they remain solid bodies. When the temperature rises sufficiently to convert them into gases, and render them at the same time luminous, the characteristic bright-line spectra are obtained. This temperature can be attained with most elements only by the use of the electric spark. A few bodies, among which are potassium, sodium, lithium, barium, calcium, strontium, and boron, yield at the temperature of the non-luminous gas-flame—Bunsen-burner flame—a limited number of rays which are early observed by the spectroscope as bright lines. Thus sodium imparts to flame a deep yellow color which

consists of two tints, and is seen in the spectroscope as a narrow double line. Potassium gives red and violet lines. By increasing the temperature some of these spectra are modified. When the electric spark is employed the spectra obtained are usually more complex, the bright lines being numerous. The detection of the different elements by this means is not so widely applicable as might at first be supposed, for the method is extremely delicate, and it is difficult to distinguish between the minute traces which often have no significance and the presence of an appreciable amount. Nevertheless, the method has been of great usefulness in special cases in showing the occurrence of some elements in unexpected relations, and the wide distribution of others in minute quantities. Several elements have been discovered by the spectroscope, occurring in such minute quantities that ordinary chemical analysis would have failed to indicate them.

There are a few rare metals which give a limited bright-line spectrum before reaching the temperature at which they became gaseous.

Absorption Spectra.—These are of several kinds. The absorption may affect a considerable part of one or both ends of the spectrum, by which a whole block of color may be cut out, or it may take place in broad bands or in fine lines. The spectrum of the sun and of many of the fixed stars is an example of this latter class. The lines of absorption are numerous, but they are narrow and represent but a small portion of the entire field, which appears to the unassisted eye to be a uniform sheet of color. Band absorption, that is, the cutting out of a considerable number of rays at some point on an otherwise continuous spectrum, is brought about very easily by means of many organic bodies.

Extended absorption, by which a considerable portion of the spectrum is absorbed, is seen in many substances possessing deep color, and the absorption may include all but a single color. Various colored glasses may be used. To test the effect of a graduated increase of color, wedge-shaped glasses may be employed. Hollow wedge-shaped cells are often used for the examination of colored liquids.

The method of observing absorption spectra has been given above. It has been also already pointed out that no description, nor even drawing, can give an adequate idea of the actual appearances of spectra, but for the purpose of completing the article and indicating some of the practical applications of the methods a few absorption spectra will be described.

Line-absorption Spectra.—Some of the rarer elements possess the peculiar property, when in solution, of absorbing special rays of light. Among the best known of these is the metal didymium, which occurs only in some moderately rare minerals. Its compounds have a delicate but distinct rose-red tint, but even when so far diluted as to make the tint not perceptible, they give several absorption-bands about the middle of the spectrum. The vapors of bromine and of nitrogen dioxide, NO_2, which to the eye have much the same color, give each a peculiar series of numerous fine absorption-lines in the central part of the spectrum. The absorption-lines that normally occur in the spectra of the sun and stars are an important clue to the chemical composition and physical condition of those bodies, but a consideration of this topic does not belong here.

Band-absorption.—One of the most familiar and striking instances of this form of absorption is seen in *chlorophyll*, which is the general term under which the green coloring matter of plants is designated. A solution of this substance is easily obtained by macerating leaves with ether or alcohol. The filtered liquid being diluted so as to be fairly transparent has a beautiful green color by transmitted light, and when viewed through the spectroscope transmits all the colors except a band in the extreme red, at which point there appears a well-marked broad dark band. The position of this band is highly characteristic of this substance, and can be detected by careful observation, even when the solution is too dilute to exhibit the color to the eye. In this way the adulteration of animal oils by vegetable oils—for instance, of lard-oil by cotton-seed oil—may often be detected, for cotton-seed oil exhibits the absorption-band of chlorophyll derived from the vegetable tissue.

Valuable use is made of absorption spectra in detecting the nature of various natural and artificial coloring matters. Fuchsine, for instance, not infrequently employed as an artificial coloring matter in wine, gives a broad but not very sharply marked band about the junction of the green and yellow of the spectrum.

It is, however, with reference to the absorption-bands produced by the fluids of the animal body that the clinical applications of the spectroscope are seen. The most important of these are the appearances seen in blood under various conditions. These appearances are due to the hæmoglobin. As ordinarily seen by examining blood much diluted with water, the spectrum is that of oxidized hæmoglobin, *oxyhæmoglobin.* The dilution must be sufficient to allow considerable light to pass, and a modification of the absorption spectrum is obtained by continually adding water until no absorption at all occurs. The same effect may be produced by examining the solution through a wedge-shaped cell, gradually diminishing the thickness of the solution through which the light passes. The effects are briefly as follows: In rather strong solution, all the light is cut off except a portion of the orange and red; when the solution is diluted somewhat, green rays are transmitted, and the dark interval between these and the orange constitutes a broad absorption-band; still further dilution produces a yellowish-green mass of light dividing the dark space into two nearly equal portions, developing, therefore, two well-marked absorption-bands. On still further diluting, the absorption becomes reduced to a single band in the yellow. When to a solution of blood of sufficient density to give the two bands we add some reducing agent, *i.e.*, some body having an affinity for oxygen, the hæmoglobin is *reduced*, and a new spectrum is obtained. For this reduction ammonium sulphide is preferred. The spectrum of reduced hæmoglobin is a single band, broader than, and not exactly coincident with, either of the bands obtained from oxyhæmoglobin, the darkest portion corresponding to the mass of light dividing the two bands in that spectrum. The chemical condition of the blood in the vessels may in this way be tested. Another important result is in determining the effect of various gases and chemical substances in blood, either by direct action or by poisoning animals and quickly subjecting the blood to examination. If we examine blood charged with nitrous oxide (N_2O), we find the spectrum of reduced hæmoglobin, but agitating the blood with air will reproduce the oxyhæmoglobin. When, however, carbon monoxide (CO), carbonic oxide, is introduced into blood, we get a new condition which gives a spectrum resembling, but not identical with, that of oxyhæmoglobin, there being two bands, but their position being slightly nearer the violet.

Furthermore, we cannot so easily restore the original condition by agitating the blood with air, nor will the ordinary reducing agents produce the spectrum of reduced hæmoglobin. Carbon monoxide is known to be one of the most active of the gaseous narcotic poisons, and the above observations show, in part, at least, the peculiar action it has on the essential breathing constituent of the blood. The carbon-monoxide-hæmoglobin—*carboxyhæmoglobin*—spectrum is seen in the blood of persons poisoned by coal-gas or fumes of burning charcoal, and an examination of the blood by the spectroscope in cases of this character may be an important medico-legal point. Another important modification of the hæmoglobin is produced by the action of sulphides, especially by hydrogen sulphide (H_2S), sulphuretted hydrogen. This gas is often present in sewer air, cesspool exhalations, and other foul places, but not invariably, nor in so great quantity as is generally supposed. When its action upon blood is examined we find a spectrum which presents the broad single absorption-band of reduced hæmoglobin (see above), but in addition a band in the red just at the junction with the orange. This band does not disappear on shaking the blood with air, although the two bands of oxyhæmoglobin appear. The body produced by the action of hydrogen sulphide on blood, and to which the properties

above described are due, has been called *sulphæmoglobin*. It has been noticed that this substance cannot be formed by the action of hydrogen sulphide on reduced hæmoglobin, which is the form which exists in the veins; hence, hydrogen sulphide may be introduced into the venous circulation without marked effect, but taken into the arterial system it is very dangerous. The difference between inhalations of this gas, by which it would get directly into arterialized blood, and its introduction into the system through the veins, has been shown strikingly in the recently employed method of treating phthisis by injections of hydrogen sulphide and carbon dioxide. In this case the gas is taken up by the veins of the portal system and excreted before it comes in contact with the arterial blood.

If a solution of blood be exposed to the air for some time it undergoes various changes, accompanied by an alteration in the absorption spectrum. This alteration can be brought about by the action of weak acids, and also of potassium permanganate, on blood. A substance called *methæmoglobin* is formed. Its absorption-bands are three, nearly coincident with those seen when sulphæmoglobin is shaken with air, but one band is more completely within the limits of the red. Methæmoglobin is believed to be a highly oxidized hæmoglobin, but its constitution is in some doubt.

Many other changes in the absorption spectra of blood are known, but while the investigation of them has much to do with physiological chemistry, the matter is too technical for discussion here. It is obvious, from what has been said, that very important medico-legal, toxicological, and even clinical questions can be determined by means of the spectroscopic appearances. The different effects produced on blood by different poisonous gases and vapors, the general symptomatology of what may be the same, offers a means of determining even *post-mortem* the character of the gas, and as an aid in the study of the so-called sewer-gas poisoning the spectroscope will be valuable.

Clinically, the spectroscopic appearances may be utilized for examining the fluids of the body either in their normal or abnormal condition. The spectrum of bile, for instance, may be utilized for the detection of it in the urine, for when the color reaction is too faint to be perceived by the unassisted eye, the spectroscope will show it. Normal urine contains a coloring matter believed to be derived from a constituent of bile, which gives a broad absorption-band on the green. In certain febrile affections another band appears, also in the green, toward the border of the yellow. Blood in urine may also be detected by the spectroscopic tests. If in solution in the urine, the absorption spectrum is seen without difficulty. If the blood be present in the form of methæmoglobin, as is sometimes the case, it will give the three bands peculiar to that body, but it is necessary to distinguish these bands from those produced by a decomposition product of hæmoglobin known as *acid hæmatin*. This distinction can be made by the use of ammonium sulphide, when, if methæmoglobin is present, the band of reduced hæmoglobin, as described above, will appear. If the blood is in the insoluble form no absorption-bands may be shown. In this case the blood is filtered and the filter paper treated with alcohol and ammonia, and then with ammonium sulphide; bands appear which are due to *reduced hæmatin* formed by decomposition.

In the accompanying map are shown some of the important absorption-spectra as seen in a refraction spectroscope of moderate power. Over the plate has been placed indications of the limits of the various colors, but these must be regarded as a mere approximation, as it is not possible to determine precisely at what point one color ceases and another begins. The dotted lines at each end of the plates represent the limits of the visible spectrum in each case, and it will be noticed that there is considerable extinction of color, especially toward the violet end. A represents the spectrum of sunlight, with some of the principal absorption-bands, and the letters which distinguish them. All these bands, as has been remarked above, are absent in the light of ordinary flames and electric lights. The observation of absorption-spectra being made with artificial light does not therefore show any such bands. B shows the absorption-bands of oxyhæmoglobin. The visible spectrum, it will be seen, extends only from green to a short distance on the red. C shows the spectrum of reduced hæmoglobin. The limits of the visible spectrum are extended slightly toward the violet. D is the spectrum of carboxyhæmoglobin, that is, of blood impregnated with carbon monoxide. E is the spectrum of methæmoglobin. F is the

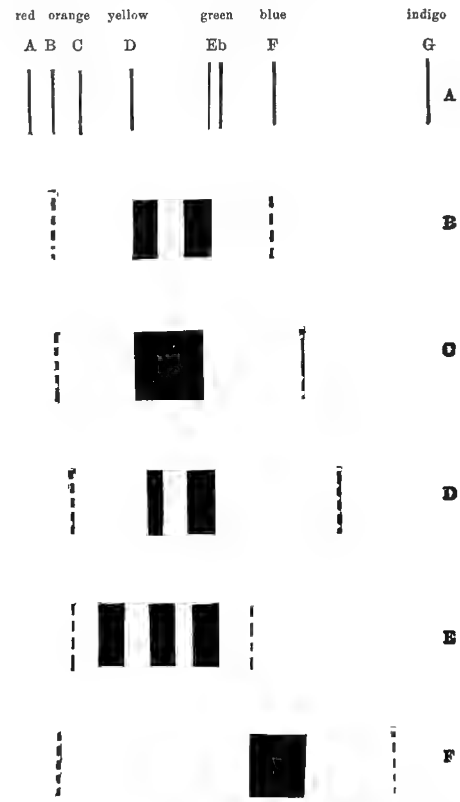

FIG. 3606.

spectrum seen commonly in normal urine. The broad band is at about the junction of the blue and green and is somewhat faint.

Very little practical clinical application, however, is yet made of these spectroscopic appearances. The instruments required are expensive and unfamiliar, and hence unsuited to the general uses of the practitioner. The use of the spectroscope in the detection of various natural and artificial colors, and in the recognition of blood-stains, belongs to special treatises.

Henry Leffmann.

SPERMACETI (*Cetaceum*, U. S. Ph., Br. Ph., Ph. G.; *Blanc de Baleine ou Cétine*, Codex Med., *Sperma-Ceti*). A solid, paraffine-like substance obtained in connection with oil, in cavities or cells in the head of the sperm-whale, *Physeter macrocephalus* Linn., order *Cetacea*.

This enormous mammal, the largest living animal, measuring from forty to sixty, or even eighty feet in length, has the general structure and shape of other whales, but is distinguished by its enormous head, one-third or more as long as the entire body, a single nostril, a very large upper jaw, which is toothless, and a much shorter and smaller lower one, bearing twenty or more pairs of conical simple teeth. Eyes small, near the base of the head; ears inconspicuous. The body tapers backward from the head, bears a small dorsal fin, and a horizontally bifurcated tail.

This whale is gregarious in its habits and is found in the ocean waters of both hemispheres, from the extreme north to the tropics. It is hunted for its oil, which is one of the most valuable of its class.

Spermaceti, or rather the crude fat, is a semi-solid, yellow substance as it is scooped out from its reservoirs, but becomes hard and brittle upon exposure to cold; for purification it is then pressed in bags, when the oil squeezes through, and the solid *cetaceum* is left behind. This can be further purified by melting in water, skimming, and recrystallization. Purified spermaceti is a pearly white, glistening, crystalline, translucent, odorless, and tasteless solid, insoluble in water; soluble in ether, chloroform, and boiling alcohol. Melting-point 111° to 112° F. It is mostly composed of *palmitic* acid combined with *cetyl* (instead of glycerine); there are also small quantities of compounds of *stearic*, *myristic*, and *lauric acids*. It is pretty permanent in the atmosphere, in this respect excelling most fats.

USE.—Spermaceti has no active medicinal qualities. It is sometimes used in sore throats, etc., where its value is mostly as a protective. Its principal employment in medicine is as an ingredient of cerates and ointments, to which it gives consistency, blandness, and permanence. The following are officinal: Cerate of Spermaceti (*Ceratum Cetacei*, U. S. Ph.), spermaceti, ten parts; white wax, thirty-five parts; olive-oil, fifty-five parts; an elegant, white, nearly odorless salve; and Cold Cream (*Unguentum Aquæ Rosæ*, U. S. Ph.), of the following composition:

Expressed oil of almond.......	fifty parts.
Spermaceti....................	ten "
White wax.....................	ten "
Rose-water....................	thirty "

ALLIED ANIMALS.—Several species of whales, besides numerous other *Cetacea*, are hunted for their valuable, and generally very permanent, oils.

ALLIED SUBSTANCES.—The ordinary solid fats and tallows, wax, and paraffine. Ambergris is a peculiar, odorous concretion found in the intestines of the sperm whale. *W. P. Bolles.*

SPERMATOZOA. In this article there is: 1, a brief summary of the structure and development of spermatozoa; 2, a fuller account of the mature spermatozoa; 3, a detailed history of spermatogenesis in mammals; 4, a few historical notes.

1. SUMMARY.—The spermatozoa of mammals are filaments, consisting of a short thicker end called the head, and a very long and delicate thread called the tail. The head varies greatly in shape, according to the species; in man it is broad and thin (Fig. 3609), and is widest at a little distance from the tail. The head contains chromatine, and may be colored by the usual nuclear dyes. The tail consists of three parts: 1, the *middle piece*, next the head, and which is the thickest of the three; it contains an axial thread, and probably always has a *very* fine spiral thread running round it; 2, the *main piece*, and, 3, the *end piece*, which is not more than a line, even as seen with very high magnifying powers. The human spermatozoon is 0.055 mm. long—the head being 0.005 mm., the tail 0.050, and the *middle piece* 0.009.

The development of the mammalian spermatozoa begins with a so-called parent- or mother-cell, which lies near the outer wall of the seminiferous tubule. The mother-cell produces a number of daughter-cells, which also multiply by division; the daughter-cells break down, forming a column of matter (protoplasm), in which lie their nuclei, and at the base of which lies the nucleus of the mother-cell; the nucleus of the mother-cell and the column of matter both ultimately disappear, but exactly how is not determined; the nuclei of the daughter-cells produce each a spermatozoon. The head and tail of the future spermatozoon become visible within the nuclear membrane; the head is formed chiefly by the chromatine of the nucleus; the nuclear membrane finally ruptures, and it, as well as the contents of the nucleus, which have not taken part in the formation of the spermatozoon, are lost; among the lost parts is a special round body of small size, which appears in the nucleus while the spermatozoon is developing; this body may be stained by chloride of gold, but not by hæmatoxyline; its significance is unknown. The long column holding the spermatozoa together has usually been regarded as a cell, and is the supporting-cell *duct*.

2. SPERMATOZOA are the essential fertilizing elements secreted by the male gland. They are minute bodies capable of active locomotion, and present always a form characteristic of the species. In a few instances (certain snails, etc.) there are two distinct forms of spermatozoon for a single species, but usually there is only one form, and that little variable. In a small number of animals the spermatozoa, as in the nematods, are distinctly cell-like, but in the great majority of animals, and so far as I know, in all vertebrates, they are long and thread-like; hence their common German name, *Samenfäden*, first proposed, I think, by Kölliker.

The mammalian spermatozoa are long, slender bodies, varying considerably in configuration (*cf.* Fig. 3607), but all presenting at least the following features in common: One end is thickened and is called the head; it has a strong affinity for nuclear staining fluids; this affinity must be attributed to the chromatine which the head contains, as is shown by the history of its development; the remainder of the spermatozoon is long and slender, and constitutes the tail; the tail consists of, 1, a middle part (Mittelstück), a little thicker than the rest, and situated next to the head; the middle part is traversed by a very fine axial thread, and ends abruptly; and, 2, a hind piece, which, according to some writers, may be subdivided naturally into two segments, the main piece (Hauptstück) and end piece.

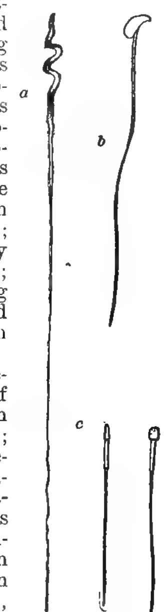

FIG. 3607.—Spermatozoa. *a*, Canary; *b*, common mouse; *c*, bat.

The spermatozoa of the various species differ in size in the proportions of the parts, and often very strikingly in the shape and structure of the head; those of the opossum are especially remarkable for being double: two apparently complete spermatozoa being united to a common plate by their heads (Selenka: "Studien über Entwickelungsgeschichte," Heft iv., p. 106). Twin spermatozoa have also been observed in the rat by Neumann (p. 313, Taf. xvii., Fig. 16, *b*).[38] Compare also Max von Brunn[12] and Brock.[9] The largest known mammalian spermatozoon is perhaps that of a marsupial, phascogale; the spermatozoon of this animal is 0.263 mm. long, the head, however, being only 0.013 mm. (Fürst, p. 354).[20] The spermatozoon of the rat is 0.144 mm. long—the head 0.009, the tail 0.135, and the "middle" piece 0.045 mm.

La Vallette[32] gives a synopsis concerning the forms of vertebrate spermatozoa nearly as follows: *Fish:* The spermatozoa of amphioxus are threads with round heads. In petromyzon the head is rod-like or egg-shaped. The teleosts generally have pin-like spermatozoa; but in the salmonidæ (Owsjannikow) the head is pointed and shaped like a heart pip. The spermatozoa of selachians are much larger, with the head end spindle-shaped and often spirally twisted. *Amphibia:* The head is long, generally pointed, the middle piece short, and the tail is often provided with an undulatory membrane (Retzius[43]). *Reptiles and birds:* The head is usually long, often twisted. *Mammals:* The head is more or less elongated, and generally, in ungulates, the head is flattened and usually more or less egg-shaped in outline, the pointed end toward the tail. Among rodents there is considerable variety of form. In the dog the head is pear-shaped; in the hedge-hog the head is truncated inferiorly and the tail is inserted laterally. No comprehensive summary of

the observed forms of spermatozoa has been made since the publication of Wagner and Leuckart's[51] article in "Todd's Cyclopædia."

The most minutely studied mammalian spermatozoon is that of the rat, thanks especially to the patience of O. S. Jensen, whose posthumous paper[28] furnishes the basis of the ensuing description. The rat's spermatozoon measures 144 μ; its head (Fig. 3608, *B*) is a broad hook, pointed at one end and obliquely truncated at the other; from one corner of the truncated end starts the very long, slender tail, which is divisible into the thicker middle piece (*Mittelstück*, or Jensen's *Verbindungsstück*) and the thinner main piece (*Hauptstück*) (Fig. 3608, *C*), which terminates in a short and still finer thread, called the end piece (*Endstück*). The appearance of the spermatozoon varies according to its degree of development, it not attaining full maturity until it has left the seminiferous tubule. The changes referred to affect principally the head and the middle piece. The head is covered, while the spermatozoon remains in the seminiferous tubules, by a membranous cap (Fig. 3608, *C*), which subsequently disappears. The middle piece has a spiral thread running round its outside (Fig. 3608, *A*). The spiral thread appears soon after the rupture of the nuclear membrane, by which the developing spermatozoon is set free (*cf. infra*). The thread is at first indistinct and makes only a few turns; it rapidly becomes more distinct, and the number of turns increases, until they become so numerous that in a spermatozoon taken from the vas deferens only a series of thick-set cross-lines can be distinguished; these lines have been seen by several observers, and variously interpreted; the spiral may run to the right or to the left. The thread becomes loosened off by the action of glycerine (1 part) and water (4 parts), and is destroyed in one to two hours by 0.6 per cent. salt solution, leaving then the axis uncovered. The thread can be stained by chloride of gold, though the axis cannot. The axis, when the spermatozoa are treated with acetic acid, often breaks up into threads (*cf.* Ballowitz[1]); it shows a lighter line in its centre. These observations lead Jensen to the conclusion that the axis is formed by a wall of fibrillæ surrounding a central core or cavity. The axis does not reach quite to the head, but ends with a little knob, leaving a small, perfectly transparent space between the knob and the head (Fig. 3608, *B*). In some spermatozoa—*e.g.*, horse and ox—though not in those of the rat, there is a minute opening in the head, called the *microporus*, and situated just opposite the knob of the axis. When the spermatozoa are stained with nuclear dyes, most of the head is colored, but the tip of the hook, which contains no chromatine, and is probably formed out of a scrap of the nuclear membrane, remains uncolored; on the concave side of the tip a fine line can be distinguished, due, apparently, to a rod of substance. Sometimes a minute fragment of the nuclear membrane is left adherent to the lower end of the middle piece; for the explanation of this possibility, compare the section below on development.

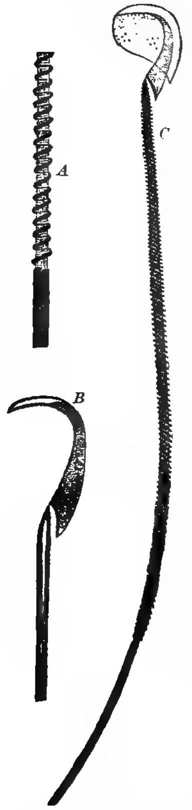

Fig. 3608.—Structure of Rat's Spermatozoon. (After Jensen.) *A*, Young spermatozoon, end of the middle piece and beginning of the main piece, to show the spiral thread—greatly magnified: *B*, head, with part of the axial thread; *C*, immature spermatozoon, anterior half only.

The human spermatozoa are described by Retzius, p. 85,[43] as follows:

The head, seen from the flat side, appears oval (Fig. 3609, *A*), with the front end generally tapering a little, but never pointed; the anterior half or two-thirds has a brighter and more transparent part. Seen on edge (Fig. 3609, *B*), the head has a pointed form, with a posterior, thicker, round, dark part. By adjustment of the focus it can be ascertained that the sides near the point are depressed, somewhat like those of red blood-corpuscles. Retzius could nowise succeed in demonstrating a special tip (Spiess) corresponding to that in the salamander. The following piece (Schweigger-Seidel's *Mittelstück*) is directly united with the head by a transverse joint; there is no neck in Eimer's sense; the middle piece is cylindrical and relatively small, about as long, or a little longer, than the head; its surface is often granular or rough, and there cling to it a few shreds of protoplasm, as has been described by several investigators; the spiral thread could not be distinguished. The *main piece* of the tail is about half as thick as the Mittelstück, gradually tapers, and ends abruptly at the beginning of the still finer and very short *end piece*. There is, according to Retzius, no membrane such as has been described by Gibbes,[22] whose account has received Krause's[30, 31] confirmation. It seems to me probable that there is a spiral thread, which may be loosened by maceration, as is the case with the rat, and that such altered spermatozoa were seen by Gibbes, and led him to assume the existence of an undulatory membrane in the human spermatozoa.

Fig. 3609.—Human Spermatozoa. (After Retzius.) *A*, Complete spermatozoon; *B*, head seen from the side; *C*, extremity of the tail. All highly magnified.

3. Spermatogenesis.—The seminiferous tubules are cylindrical, *i.e.*, in cross-sections they appear round; a large part of the tubule is filled with spermatozoa in various stages of development. The outer boundary is marked by a distinct line corresponding to the tunica propria, a layer of endothelial cells, with flat oval nuclei (Neumann,[38] p. 306). Next to the tunica comes a layer which, as far as known, presents pretty much the same appearances, whatever may be the stage of development of the spermatozoa within. This layer contains two kinds of cells: *First*, the large Sertoli's cells, as they may be called after their discoverer.* These cells are identical with Merkel's Stutzzellen, La Vallette's spermatogonien, Swaen and Masquelin's cellules folliculaires. *Second*, smaller granular cells.

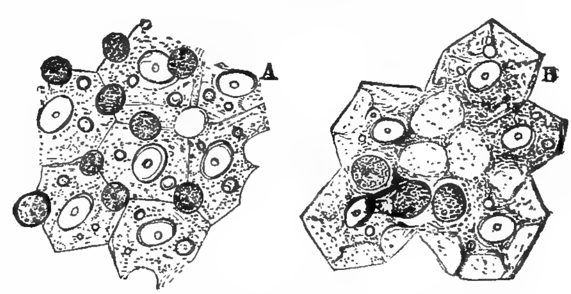

Fig. 3610.—Peripheral Layer of the Seminiferous Tubule of a Rat. Two views from a teased preparation. (After Neumann.)

Examined in surface views (Fig. 3610) (compare also Figs. 5, 6, and 41 of Furst's paper[20]), the *large cells* are seen to be mostly hexagonal in outline, to touch one another, and to pass below, *i.e.*, outside, the small cells; they have large, clear, oval nuclei, with sharp outlines, and usually a single, well-marked nucleolus. The nuclei lie quite near the tunica propria, but in man lie farther inward, and are in this case not so near the tunica

* First described by Sertoli in H. Morgagni (cf. Henle's Jahresbericht for 1864, p 120). Compare Sertoli, Arch. Sci. mediche, ii., 107 (1877).

as are the small cells. Around the nucleus there lie a few highly refractile granules, which may be stained by osmic acid, and are probably fat. The small cells lie in depressions or cups of the large cells (Fig. 3610, *B*), and when the small cells are knocked out—as sometimes happens in teasing—the partitions between the cups appear more distinctly and create a network figure, which has misled von Ebner and others into describing a real network as constituting the layer. The large cells also have long columnar prolongations, as can be best seen in transverse sections of the tubules (compare Fig. 3616); the prolongations are united with bundles of developing spermatoblasts. The *small cells* are very different; they lie over the outlines of the large cells, and between their centripetal prolongations (compare Fig. 3616); they are granular, have comparatively little protoplasm, and nuclei more or less nearly spherical in shape. The nuclei vary considerably in appearance, as these cells multiply by indirect division; usually they contain a chromatine network or a coiled chromatine cord; sometimes the network is concentrated at one side of the nucleus, leaving the other side comparatively clear. At certain periods the nuclei are found in various stages of karyokinesis. The cells resulting from the division of the small cells form the packing between the inward columns of the large cells, hence in cross-sections we get alternating columns (Fig. 3616). The descendants of the small cells produce the *spermatoblasts*, and the spermatoblasts are converted into the spermatozoa. The small cells are then the parents of the spermatozoa, and may be called the parent-cells; a great variety of names have been employed to designate them, such as mother-cells, spore-cells, germinative cells, Samenstammzellen, etc.

Formation of the Spermatoblasts.—The parent-cells divide and produce probably two daughter-cells, although the number has never been accurately ascertained. According to Biondi,[5] the nucleus of the parent-cell remains and becomes like the nucleus of the large cells (Sertoli's or supporting cells). The daughter-cells divide, and their descendants also divide, until there is produced a column of cells (Fig. 3611), which stretches in a radial line from the mother-cell toward the centre of the tubule, and is packed in between the columnar centripetal prolongations of Sertoli cells (*cf.* Figs. 3611 and 3616). Probably, then, although investigators are not agreed in regard to this point, the mother-cells divide in such a way that the cells resulting from the division are unlike—one of them preserving the character of the mother-cell, and the other differing from it in having a relatively larger nucleus and a finer chromatine network; the appearance of the nuclei varies, of course, according as they are in the resting or divisional (kinetic) phase.* The cell most like the original one, and which we may call still the mother-cell, lies at the outer edge of the tubule, while the other, or first daughter-cell, lies toward the centre (Fig. 3611). The mother- or parent-cell, as already stated, produces at least a second, and perhaps more daughter-cells, so that the column grows centripetally. The column also grows by multiplication of the daughter-cells, but the cells thus formed lie in the innermost part of the column; they are smaller (Fig. 3611) than the first generation of daughter-cells; they have relatively large nuclei, with the chromatine gathered into two or three spots—nucleoli. We thus have a column of cells in which we can distinguish three zones: 1, The outer zone of the mother-cell; 2, the middle zone of the daughter-cells; 3, the inner zone of the second generation of daughter-cells. These zones remain more or less marked for a considerable period, for, as the cells of the inner zone change into spermatoblasts, those of the middle zone change into second daughter-cells, and as the inner spermatoblasts change into spermatozoa, the cells of the second zone change into spermatoblasts; the innermost zone long continues one stage ahead. The tri-zonal arrangement is very conspicuous in cross-sections.

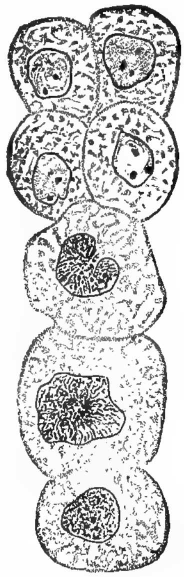

Fig. 3611.—Column of Spermatocytes from the Rat. × 600. (After Biondi.)

* For figures of the karyokinetic division of the daughter-cells, see Fürst, Figs. 10–13.[20]

The division of the daughter-cells presents many peculiarities, and does not conform exactly to Flemming's well-known scheme of phases for indirect division. Attention was first directed to these peculiarities by Carnoy, in an important memoir.[13] Flemming[19] has since confirmed these discoveries, in large part, by observations on the salamander, and gives a plate of diagrams which is instructive as a facile means of comparison.

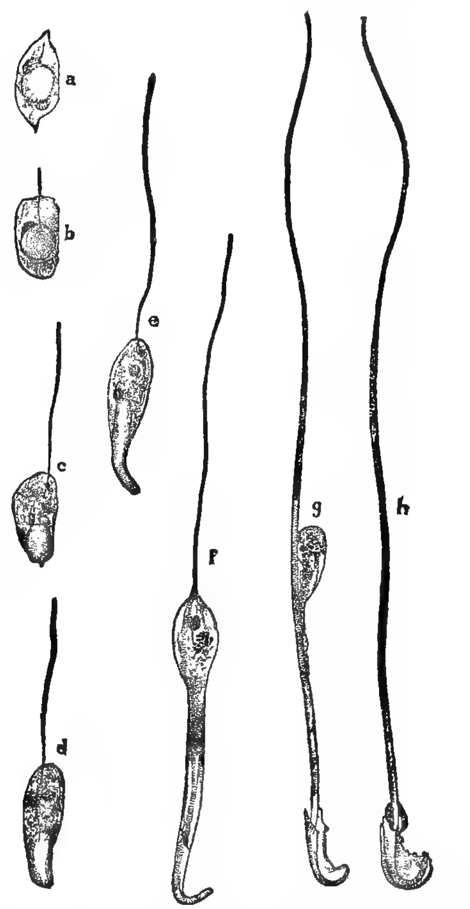

Fig. 3612.—Developing Spermatoblasts of the Rat. *a, b, c, d, e, f, g, h*, Successive stages. × about 750 diameters. (After H. H. Brown.)

The spermatoblasts arise from the nuclei of the second daughter-cells (spermatocytes), and not as Brown[10] and many others have, I think, erroneously believed, each out of a whole cell. Biondi[5] seems to me right in his statement that the bodies of the cells break down, or at any rate lose their boundaries, thus creating a granular protoplasmatic column in which the nuclei lie. The mother-cell participates in these changes, hence its nucleus comes to lie at the base of the column. This nucleus has meanwhile altered its character, and become large, clear, and nucleolated. Now, these columns are the same as the large Sertoli's, or supporting cells above described. By no means all writers agree with this account of the origin of Sertoli's cells, but all other explanations that I

have found appear to me vague and confused, and the history of the changes here advocated is clear, and accounts for the well-established grouping of the spermatoblasts in the substance of Sertoli's column; this essential phase is explained satisfactorily by no other theory.

The nuclei congregate at the inner end of the column, and there change their character and become recognizable spermatoblasts (Figs. 3612 and 3616).

Development of the Spermatoblasts into Spermatozoa.—The nuclei change into spermatozoa as follows: The chromatine is at first unequally distributed throughout the nucleus; it then in great part accumulates at the end of the nucleus toward the outer wall of the tubule; particles of the chromatine are said to remain in other regions of the nucleus, and finally to gather together to form the small accessory corpuscle mentioned below. The main mass of the chromatine is concerned in the formation of the head of the spermatozoon; it is at first quite round (Fig. 3612, *a* and *b*), but soon begins to alter its shape, gradually assuming the form of the spermatozoon head (Fig. 3612, *c, d, e, f*). The tail appears very early as a delicate filament, lying entirely within the nucleus (Fig. 3612, *a*), but shortly after is found to project beyond the nuclear membrane *b*, and lengthens rapidly, *e, f, g*. The nuclear membrane is very distinct; it elongates into an oval bag, *b, c*, one end of which lies close against the chromatine, while the other surrounds part of the tail and is wide; the lengthening continues, *e, f, g*, with accompanying changes of form, best indicated by the figures; the part of the tail within the nuclear membrane becomes the middle piece (Fig. 3613), but the spiral thread is not developed until later. The accessory body may be readily seen in the rat; unlike the chromatine of the head it can be stained by chloride of gold, hence if it is formed of chromatine at all, the chromatine must have undergone alteration. Finally, the nuclear membrane ruptures (Fig. 3614), a portion of the membrane remains upon the head, and the caudal bag sometimes endures longer (Fig. 3612, *g*), but at last also disappears, except that in certain cases a trace of it remains visible as a fine cross-line at the end of the middle piece. Fürst and others think that the axis of the tail is formed from the chromatine, and that the sheath of the axis arises from the achromatic substance of the nucleus (caryoplasma). After the rupture of the nuclear membrane, the young spermatozoa still develop a little further. The spermatozoa are ultimately liberated, and, falling into the lumen of the tubule, pass off.

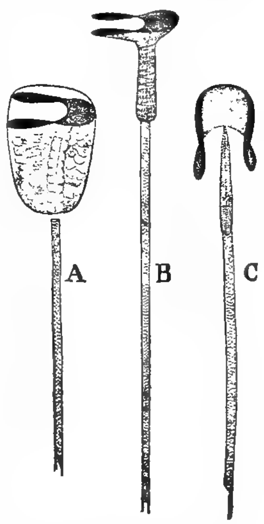

FIG. 3613.—Developing Spermatozoa of a Marsupial, Metachirus Quica. A, B, C, different stages. (After Fürst.)

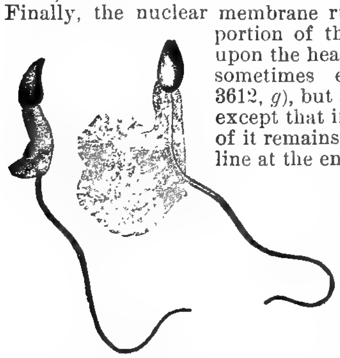

FIG. 3614.—Human Spermatoblasts, to Illustrate the Rupture of the Membrane. (After Wiedersperg.)

From their mode of development, it is evident that the spermatozoa necessarily lie in bundles, each bundle being held together by a Sertoli's column (Fig. 3615); at first they lie at the inner end of the column, at a considerable distance from the basal nucleus (Fig. 3615), but as the nuclei (spermatoblasts) lengthen, the heads push their way toward the base of the column (Fig. 3616). Now, as the development of the daughter-cells (spermatocytes) is continually progressing between Sertoli's columns, we obtain in sections the long-known remarkable appearances shown in Fig. 3616, of bundles of spermatozoa alternating with columns of proliferating cells.

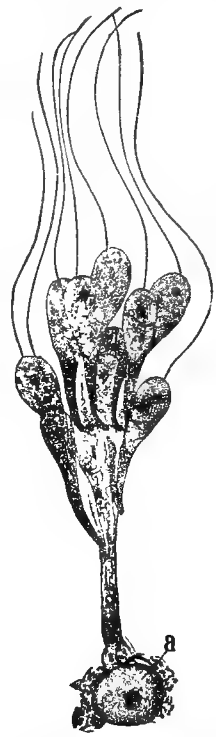

FIG. 3615.—Sertoli's Column, with a Basal Nucleated Nucleus and a Cluster of Developing Spermatoblasts. (After H. H. Brown.)

4. HISTORICAL. — The seminal animalcules were, it is stated, first discovered by Ludwig Hamm, then a student at Leyden, in August, 1677. Loewenhoeck claimed the merit of having made the discovery in November of the same year, and in 1678 Hartsoeker published an account of them, professing to have seen them as early as 1674. They were long considered to be probably parasites, and it was not until Prevost and Dumas's researches that it was definitely ascertained that the "animalcules" were the essential fertilizing element. Thus Richard Owen, in his article on "Entozoa" (1836), in "Todd's Cyclopædia," includes the spermatozoa under that head, although he writes—"it is still undetermined whether they are to be regarded as analogous to the moving filaments of the pollen of plants or as independent organisms" (vol. ii., p. 412). But just after he adds: "Although no distinct organs of generation have been detected, there is reason to suspect that the *spermatozoa* are oviparous; they are also stated to propagate by spontaneous fission, the separation taking place between the disk of the body and the caudal appendage; each of which develop the part required to form a perfect whole."

Meanwhile the investigations of Spallanzani, Wagner, Czermak, and many others, gradually increased the knowledge of the forms of the spermatozoa. Dujardin[15] was the first to consider the spermatozoa as generated from the inner layer of the seminiferous tubules, and, therefore, not as parasites. The discovery of the spermatoblasts, or immature spermatozoa, by von Siebold (Müller's *Archiv*, 1836 and 1843), soon confirmed by Kölliker and Reichert,

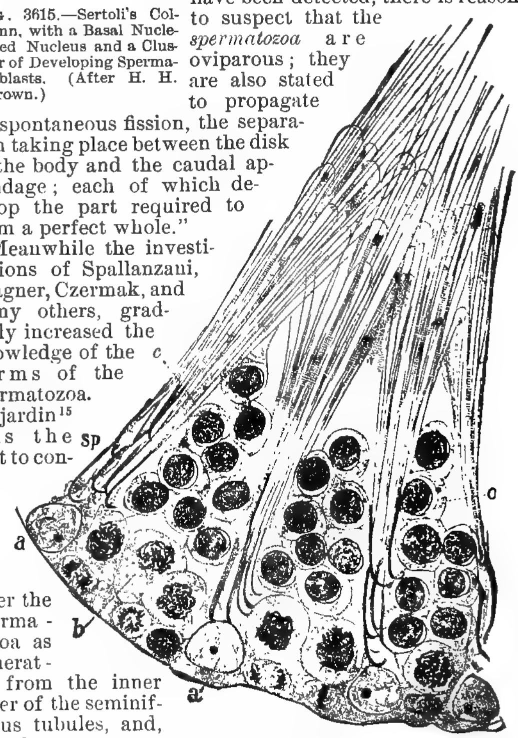

FIG. 3616.—Part of a Cross-section of a Seminiferous Tubule of a Rat. × about 750 diameters. (After H. H. Brown.)

marks an important step. Now followed a series of publications by which one detail after another was added to our knowledge. During the past twenty years there has been rapid progress, which may be said to have begun with Schweigger-Seidel's important memoir,[45] and to have made us acquainted with the minute structure of the spermatozoa, and their development. Another line of investigation was opened by O. Hertwig (1875), in following up the history of the spermatozoon within the ovum after impregnation. For further historical data see Waldeyer's address[52] (1887).

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55 Zacharias: Arch. mikrosk. Anat., xxx., 111.

Charles Sedgwick Minot.

SPHYGMOGRAPH AND CARDIOGRAPH. Instruments for obtaining graphic representations of the pulse-movements of the arterial wall, or of the movements imparted to the chest-wall by the impulse of the heart. They cause a lever or style, which follows and magnifies the movements, to write upon a surface passing at a constant speed, and thus trace a record of the rhythmical movements in a series of curves. In order to fulfil the fundamental requirements, such instruments should accurately follow the pulse-movements, without modifying them by their own inertia; they should magnify the movements sufficiently to permit convenient study of their record; and the rate at which the recording surface moves should be reasonably constant, so that the time occupied by the various phases of the movement can be calculated.

A great number of instruments have been devised, which meet these conditions more or less successfully. The first-named requirement offers the only problem difficult of solution. The first useful sphygmograph, the curves of which have been shown to represent the actual movements of a pulsating artery, was introduced by Marey, the great master of the graphic method, in 1860. Before him the most important apparatus designed for the same end was the sphygmograph of Vierordt (1855), who failed to register the real movements of the pulse only from his anxiety to produce curves like those of the kymographion—an instrument which indicates the variations of mean blood-pressure with great exactness, but does not follow the quick and delicate variations of the pulse. The sphygmograph of Marey (originally constructed for the radial artery alone) was at once employed not only by physiologists, but by clinicians, and added sphygmography to the methods of clinical investigation. It has since been variously modified and improved, and the principle of its construction—"*sphygmographe à pression élastique*"—is the basis of most of the instruments now in common use. Moreover, it has been critically tested by other competent observers, and has been found to answer the requirements of an instrument of precision, in spite of certain limitations.[1]

ELASTIC SPRING SPHYGMOGRAPHS.—*Marey's sphygmograph.* A rather strong elastic steel spring, *a*, Fig. 3617, is fixed by one end, *b*, to a frame of brass to be applied to the forearm, while its other (free) end is provided with a thin ivory button, *c*, intended to press upon the radial artery at the wrist. The pulse-movements communicated to this button are transmitted to the lever by means of an upright toothed rod, *d*, which presses against a small similarly toothed wheel, *e*, turning on an axis to which the light wooden lever, *f*, is fastened. Every movement of the upright turns the wheel and elevates or depresses the lever. The axis of the lever revolves in a bearing in the end of the frame which rests upon the wrist. The other end of the brass frame, to which the spring is fastened, supports a clockwork,

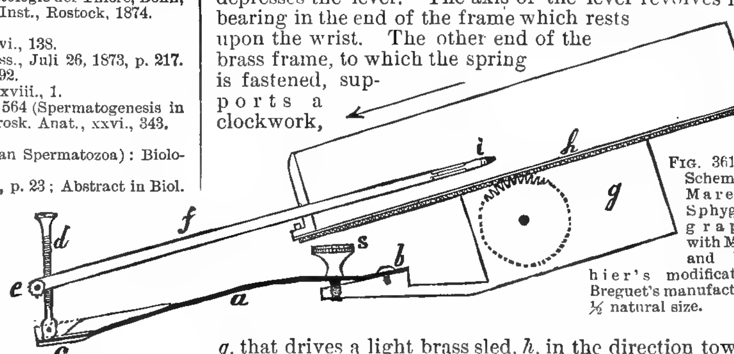


FIG. 3617.—Scheme of Marey's Sphygmograph, with Mach and Béhier's modification. Breguet's manufacture. ½ natural size.

g, that drives a light brass sled, *h*, in the direction toward the wrist, as indicated by the arrow. This sled carries the recording surface of smoked paper or glass upon which the end of the lever—a fine-pointed style, *i*—scratches its record.

The described connection between the spring and the lever, by means of the toothed rod and cog-wheel, is a modification by Mach[2] (1863) and by Béhier[3] (1868), and is now used in all the instruments made by Breguet. The rod is movable on an axis in a brass plate on the free end of the spring, so that it can be laid flat upon the latter while the sphygmograph is being adjusted to the arm, and lifted up against the toothed wheel of the lever when the instrument is set in action. The spring itself keeps it closely applied to the cogs of the wheel.

The pressure of the spring upon the artery is modified by means of the screw *s*, which presses the spring downward with greater or less force. While by this means the pressure can be varied, it cannot be measured. To obviate this defect Burdon-Sanderson (1867) introduced a modi-

fication, by which the instrument is at the same time more securely fixed to the wrist. Removing the wings by which Marey binds the frame upon the forearm, he

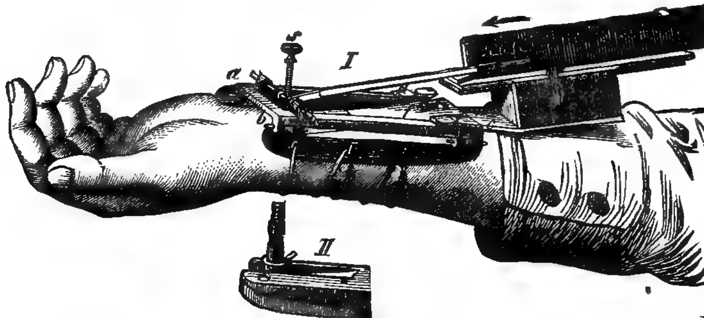


FIG. 3618.—*I*, Marey's Sphygmograph. Applied; *II* shows the manner in which the upright toothed rod of Béhier is joined to the end of the spring. (Rollett, in Hermann's Hdb. d. Physiologie, Bd. iv.)

adjusts to the end of the instrument (between the letters *a* and *b* in Fig. 3618) "a rectangular block of brass, by the under surface of which [covered with ebonite] it rests on the tendon of the *flexor longus pollicis*, and on the space between that tendon and the spine of the radius; the block being kept closely applied to the surface by means of a strong elastic band which encircles the wrist."[4] By means of a screw the distance between the ebonite surface and the frame is varied at will and the pressure modified; the amount of the pressure is measured by the deflexion of the spring (the distance between the spring and the lever) as determined by experimental test. Mahomed[5] (1872) substituted for the screw *s*, which in Marey's sphygmograph varies the pressure of the spring, an excentric wheel M (Fig. 3619), graduated in accordance with the degree of pressure, so that the latter may be read off at once.

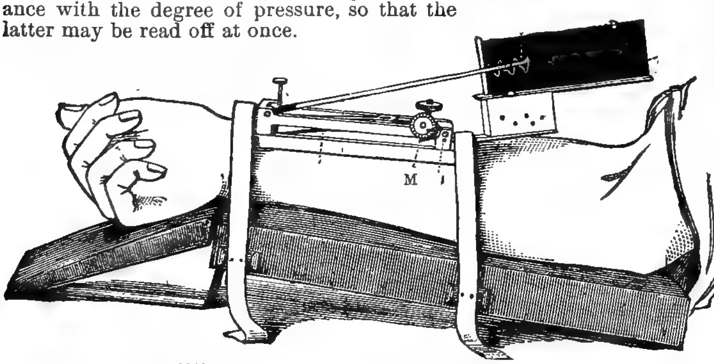


FIG. 3619.—Mahomed's Sphygmograph, Applied. (Bramwell.)

Marey's instrument is fixed to the forearm by means of japanned wings hinged to the frame, which are provided with hooks, and a silken cord passed under the arm from hook to hook. This mode of adjustment is defective. Mahomed's sphygmograph is more securely attached, by

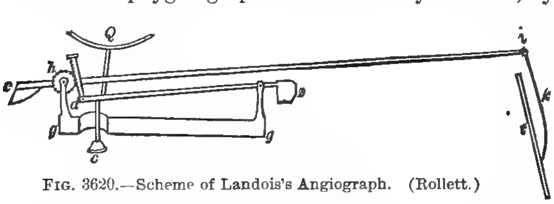


FIG. 3620.—Scheme of Landois's Angiograph. (Rollett.)

means of two straps, one at each end of the frame, to a supporting pad placed under the arm, as seen in Fig. 3619.

INSTRUMENTS IN WHICH THE PRESSURE IS EXERTED BY WEIGHTS.—Instead of the elastic spring pressure, methods have been devised for applying the pressure by weights, which afford the advantage of numerical accuracy. Such are the modification of Marey's sphygmograph by Baker[6] (1867), the angiograph of Landois[7] (1872), the sphygmograph of Sommerbrodt[8] (1876), and the *sphygmographe passif* of Brondel[9] (1878). Baker and Brondel replace the steel spring of Marey's instrument by sliding weights; the most important contrivance for carrying out the principle of pressure by direct weight, however, was invented by Landois.

Landois's Angiograph.—On the proximal end of a plate, *g*, *g*, (Fig. 3620), that serves as the base of the instrument, is balanced on an axis the solid rod *d*, *z*, which takes the place of the spring in Marey's sphygmograph; to its longer arm, near *d*, are attached, below, a stem carrying the button *c*, which explores the artery, and above, a stem carrying a dish or scale, *Q*, for holding the weights, and a toothed rod which, as in Béhier's modification, moves the toothed wheel *h*, attached to the spindle of the writing lever. This lever bears upon its extremity a light needle, *k*, hung from the joint *i* in such manner that it falls by its own weight upon the smoked plate *t*; this plate—the recording surface—is moved by clock-work at right angles to the plane of the lever (and to the forearm).

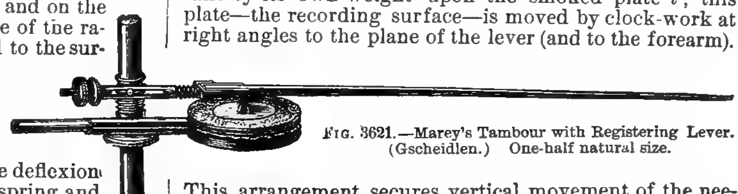


FIG. 3621.—Marey's Tambour with Registering Lever. (Gscheidlen.) One-half natural size.

This arrangement secures vertical movement of the needle instead of the curved movement of the style of Marey's sphygmograph, as well as the least possible friction in the tracing apparatus, but at the same time involves a clumsiness which detracts from the convenience of the instrument. The lever itself, as well as the rod *d z*, with all its attachments, being balanced by counterpoises, *e* and *z*, the pressure upon the artery is exerted only by the weights placed in the scale.

Sommerbrodt made use of a like accurate method of pressure by weights in his somewhat complicated modification of Marey's sphygmograph.

TRANSMISSION SPHYGMOGRAPHS, POLYGRAPHS, PANTOGRAPHS.—A new principle in the construction of pulse-writers was introduced by Marey (1863), following the methods of Upham and Buisson, in his instruments "*à transmission.*" With the help of a suitable mechanism the pulsatory movements are conveyed to a Marey's *tambour* or tympanum, which is put in communication, by a flexible tube, with a second tympanum. The second tympanum carries the writing lever.

The tympanum is a shallow capsule of metal covered by a caoutchouc membrane, the centre of which bears a

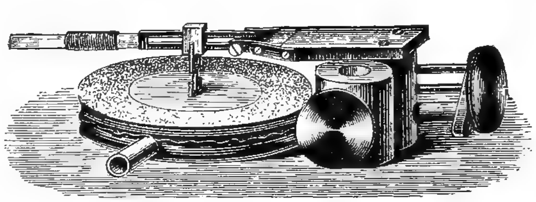


FIG. 3622.—Marey's Registering Tambour; new construction. (Gscheidlen.) Natural size.

very light round metal (aluminium) plate. In the second (or registering) tambour this plate is provided with a

wooden bridge or knife-edge upon which the writing lever rests. Figs. 3621 and 3622 show the details of construction of this apparatus, now well known in the physiological laboratory. The expanding movement of the artery compresses the air in the first (or receiving) tambour and forces a part of the contained air into the second tympanum, whose membrane is thereby raised and lifts up the lever placed upon it. The lever magnifies the movements.

The recording surface may be so large and so constructed

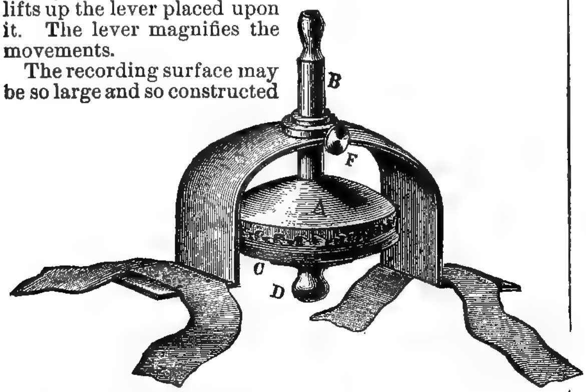


Fig. 3623.—Receiving Tympanum of Brondgeest's Pansphygmograph. (Gscheidlen.) One-half natural size.

that a number of levers can register upon it at the same time, one exactly under the other, and the pulse-movements from two or more sources can be inscribed upon it synchronously; such instruments have been called *polygraphs.*

Sphygmographs of this construction differ mainly in the mode of application of the receiving tambour to the pulsating surface; many of them can be applied to any pulsating artery, as well as to the chest-wall over the impulse of the heart, and are known collectively as

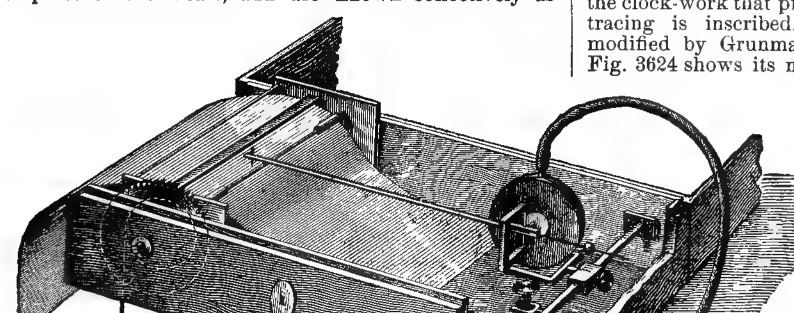


Fig. 3624.—Grunmach's Modification of Meurisse and Mathieu's Polygraph. (Gscheidlen.) One-fourth natural size.

pantographs. Many cardiographs (see below) are constructed on this principle, which was, indeed, first used for demonstrating the movements of the heart by Upham, Buisson, and Marey. Brondgeest (1873), in his *pansphygmograph,* devised a mechanism for applying the tambour to all pulsating surfaces; the capsule A (Fig. 3623), whose elastic membrane, C, is provided with a button, D, is held over the vessel by means of a metal bow in which its short metal tube, B, is fastened by a screw, F, in such manner that the button bears upon the artery with the necessary degree of pressure. The tube B is connected by a caoutchouc tube with the registering tambour. Two systems of tambours, or three,

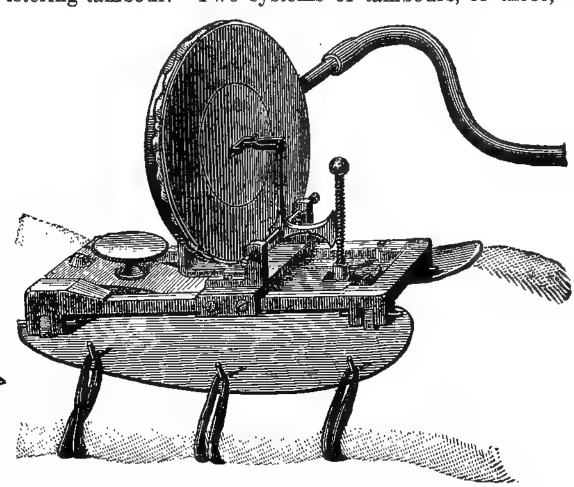


Fig. 3625.—Marey's *Sphygmographe à transmission.* (Ozanam.)

can be employed to register movements upon a revolving cylinder simultaneously.

Meurisse and Mathieu (1875) made use of a more complicated receiving apparatus, adding spring-pressure; they also placed the recording apparatus, for greater clinical convenience, in a portable box which contains the clock-work that propels a strip of paper on which the tracing is inscribed. This sphygmograph has been modified by Grunmach (1876) and by v. Knoll (1879). Fig. 3624 shows its modern form. The exploring button D is detached from the capsule; it is carried on the end of a curved steel spring, B C, rising from a horse-shoe plate, which serves as the base; the degree of pressure of the spring is regulated by the screw E. The capsule is held over the button by two vertical rods fixed upon the base-plate, so that the stem of the button touches the centre of the membrane of the tambour. The latter is set higher or lower by a ratchet mechanism. The use of the spring-pressure in connection with the transmission-apparatus seems to have been suggested by Burdon-Sanderson's cardiograph (see below).

In Marey's *sphygmographe à transmission* (1878) (Fig. 3625), spring-pressure is also used, the mode of application being the same as in his elastic-spring sphygmograph; the same frame, without the clock-work, carries a steel spring and a Béhier-Mach grooved stem, which rests against one end of an angular lever; the other end of this lever touches the centre-plate of the receiving tambour, which is set upright facing the wrist. Dilatation of the artery raises the spring, presses the lever against the membrane of the tambour, and, by compression of the air within, raises the membrane of the recording tambour and lifts the writing lever.

Keyt,[10] of Cincinnati, starting with a "sphygmometer" of his own invention, similar to the old sphygmometer of Hérisson and the sphygmoscope of Naumann, evolved the "compound sphygmograph," which Fig. 3627 shows in its most complete form—a transmission sphygmograph, in which water is used as the medium, instead of air. His sphygmometer was a graduated glass tube, eight or

ten inches long, with an exploring "base" of brass (Fig. 3626), "semicircular in form, with an oblong free edge below, and a shallow neck into which is inserted, air-tight, the glass tube." The free edge of the base, one and three-eighths by three-eighths inch, is closed by a rubber membrane. This base is used in the perfected instrument for receiving the pulse movements. When the base is pressed upon the artery, the water in the tube follows the movements of the arterial wall. He then closed the top of the tube (filled with water) by a rubber membrane, and placing on this a pin and lever, was ready to register the enlarged movements on a passing plate. In the complete instrument (Fig. 3627) there are supplied two exploring bases, each with its tube and lever, one of which registers exactly below the other. The communicating tubes are made of stiff rubber, or of glass with rubber joints, so that the bases can be freely moved. The upper end of the tube is now a metal cylinder closed by a rubber membrane. Each base can also be put in communication with a manometer tube indicating the degree of pressure applied. The registering plate is driven by a clock-work, and receives, besides the tracings of the lever, the simultaneous markings of a chronograph. The instrument thus becomes one of the best polygraphs, and lends itself especially to the study of the synchronism or succession of events in the circulation.

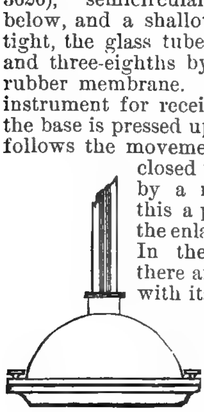


Fig. 3626.—Base of Keyt's Sphygmometer and Sphygmograph. (After Keyt.)

Keyt asserts that in his manner of employing water as the medium for the transmission of movements, the inertia of the water does not become obnoxious, and its power of transmission is greater than that of air. His tracings seem to bear out this claim. But when Ozanam, in his sphygmograph,[11] resorts to the much heavier medium mercury, the resulting curves are scarcely more than the records of rhythmical oscillations of the mercury.—— Facility of application and clinical convenience have been consulted in two instruments, which have been used more extensively by physicians, perhaps, and which have bred more amateur sphygmographers than any others, in America as well as in England and Germany—those of Pond (Vermont, 1877) and of Dudgeon (England, 1878–80).

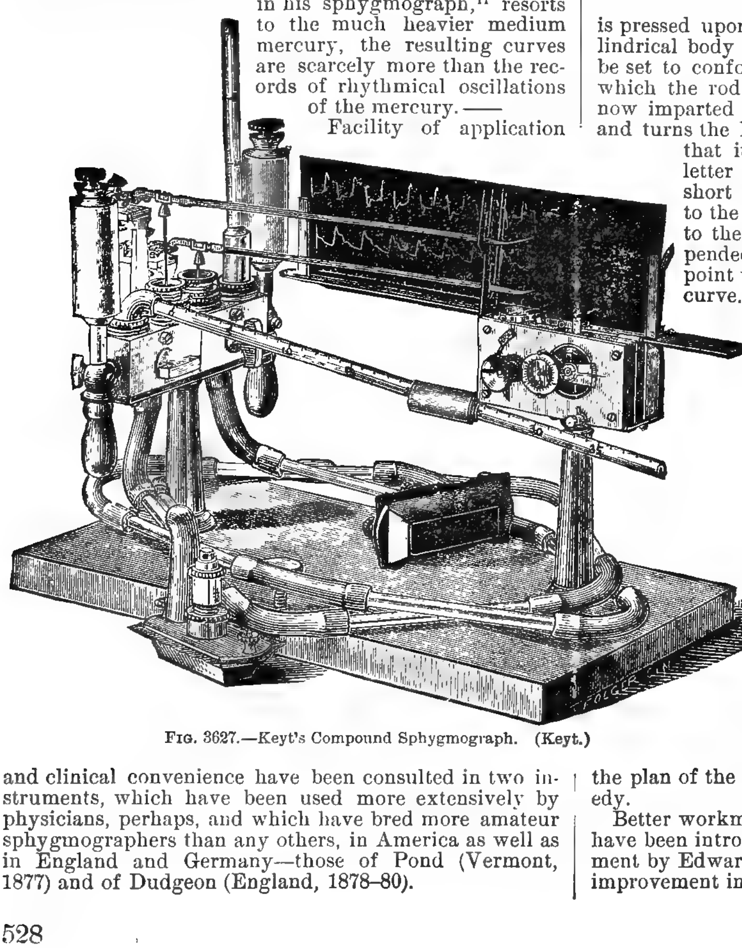


Fig. 3627.—Keyt's Compound Sphygmograph. (Keyt.)

Pond's sphygmograph, in its present form, when in use, is held in the fingers by the hollow cylindrical body *a*, (Fig. 3628) and the necessary pressure is thus exerted on the artery more readily, and quite as steadily, as by use of the arm-rest furnished with the instrument in its earlier phases. The foot of this body is an oval metal capsule, *b*, closed by a pure-rubber cap; the base is thus made of a slightly stretched elastic membrane, which is made more or less tense according to the pressure used. Upon this membrane rests a small metal plate bearing an upright rod, which moves loosely within the body and terminates in the button *c*. From the upper part of the body spring two metal arms, one of which supports the clock-work *d*, and a stage, *e*, for the card-board or mica slide on which the trace is written (the slide moves, in the figure, at right angles to the plane of the paper, and toward the spectator). The other metal arm bears the system of levers and the writing-needle.

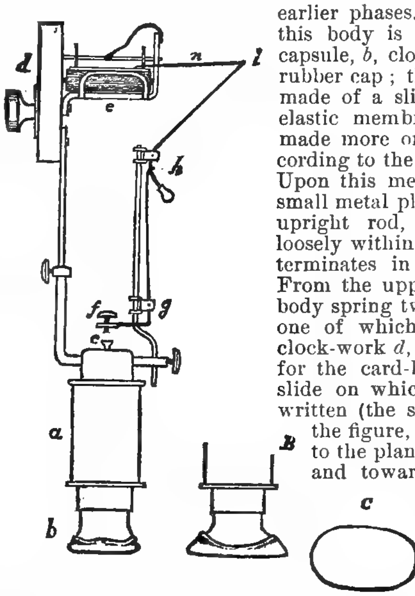


Fig. 3628.—Scheme of Pond's Sphygmograph. *B*, Side view of the base; *C*, shape of rubber membrane closing the bottom of the base. One-half natural size.

When the instrument is pressed upon the artery the rod concealed in the cylindrical body rises and touches the screw *f*, which can be set to conform to the pressure, *i.e.*, to the height to which the rod is lifted; any further upward movement now imparted to the rod by the pulse raises the screw and turns the lower lever about the pivotal point *g*, so that its upper end moves outward toward the letter *h*. This end, by a loop, embraces the short arm of the second lever, and, pushing it to the right (in the figure), moves its long arm to the left. From the end of this lever is suspended, by the loose joint *i*, the needle *n*, whose point rests upon the slide and traces the pulse-curve. The short arm of the upper lever ends in a counterpoise, which by its weight secures the return of the lever when the upward pressure is withdrawn. In this instrument, the pressure made over the artery is that of the more or less tense rubber membrane at the base.

The defects of this instrument are obvious. The weight of the levers and their counterpoise is so great, as compared with that of the rod, which lies loosely upon the membrane of the base, that the inherent vibrations of the apparatus make themselves felt in the curve. The excursions of the needle are limited to the distance of the upper lever (at rest) from the stage on which the slide travels, which is not much over half an inch; the tracing cannot be higher than this; if the lever strikes at either extremity of its course, the curve is vitiated. This imperfection could be easily removed; the former defect pertains to the plan of the instrument, and is more difficult to remedy.

Better workmanship and some modifications in detail have been introduced in the construction of this instrument by Edwards (Buffalo, 1880), but without apparent improvement in the results, as Hopkins' curves testify.[12]

Dudgeon's sphygmograph combines in an ingenious manner the steel spring of Marey with the registering mechanism of Pond. A rather short steel spring, A, Fig. 3629, whose pressure is regulated by a Mahomed's eccentric, N, indicating ounces, is provided at its free end with a movable exploring button, B, and transmits its movements to the writing-needle L, by a system of levers on the plan of Pond, as seen in the illustrations (Figs. 3629 and 3630). The whole instrument is given a more compact form, and is fastened to the wrist by a single strap, the tightening of which can be usefully controlled by the fingers of the experimenter. This mode of application has some advantages. The use of the steel spring is a decided improvement upon the rubber membrane of Pond's sphygmograph; the system of levers is, however, as in Pond's, subject to vibrations of its own which are apt to mar the curve.

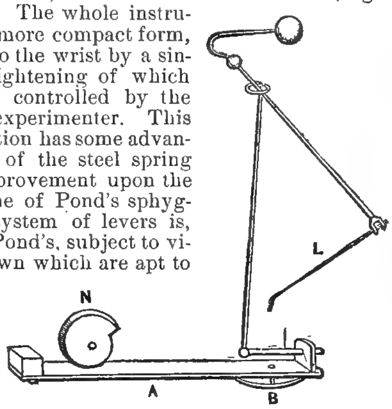


Fig. 3629.—Scheme of Dudgeon's Sphygmograph. (Dudgeon.) Natural size.

CARDIOGRAPHS.—The principle of transmission was first carried out in the older form of Marey's cardiograph (1865) (Fig. 3631). The receiving mechanism of this instrument was, however, defective and has been replaced by a later device in 1875. The transmission instruments intended for the heart are now constructed with a receiving tambour, whose earliest and simplest form was embodied in Brondgeest's pansphygmograph (1873), already described. Burdon-Sanderson, in the same year, added the elastic curved spring, and supported the exploring tambour on an adjustable tripod which was fastened over the heart by straps passing round the chest. The receiving apparatus of Meurisse and Mathieu (1875), and its modifications by Grunmach and v.

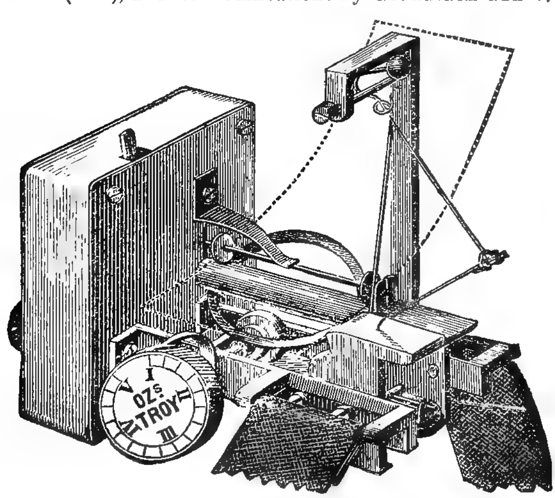


Fig. 3630.—Dudgeon's Sphygmograph. (Dudgeon.) Natural size.

Knoll (1876, 1879), which also presses the exploring button upon the pulsating surface by means of a curved spring, has been described before. Marey (1875) improved his instrument by inclosing the receiving tambour, furnished with a central button, in a cylindrical capsule, in which a spiral spring exerts the necessary pressure (Fig. 3633). In all these transmission instruments the registering apparatus is constructed on similar principles.

Keyt's compound sphygmograph, transmitting movements through water, as before described, is as well adapted for recording the apex beat as the arterial pulsations.

Marey's sphygmograph in its ordinary forms has also been extensively used for the exploration of the heart's impulse, and with excellent results, *e.g.*, by Landois. It

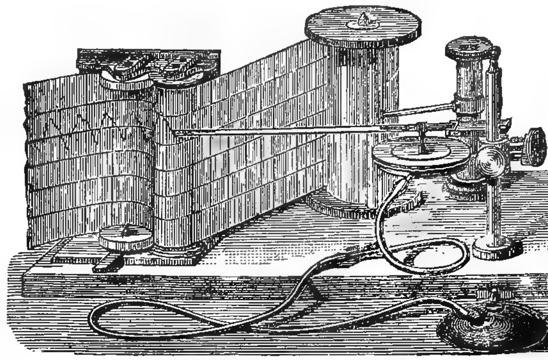


Fig. 3631.—Marey's Cardiograph, original form. (Ozanam.)

has also been specially adapted to use as a cardiograph by Galabin[13] (1872). He suspends a Marey's sphygmograph, of the Mahomed pattern (so modified that the magnifying power of the lever can be varied at will from ten to about a hundred), from two transverse rods held

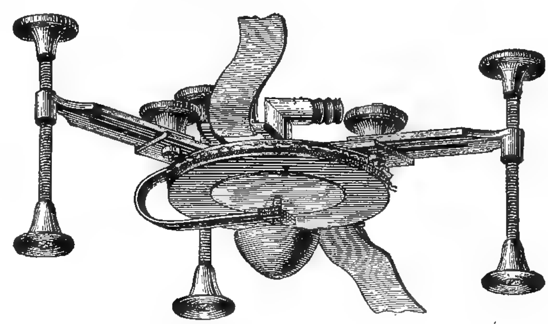


Fig. 3632.—Burdon-Sanderson's Cardiograph, Receiving Apparatus. (Gscheidlen.) Natural size.

up by four vertical rods inserted into two bars of wood covered with leather, which rest upon the chest. The attachment of the transverse rods to the vertical supports permits their being raised or lowered at either end, so that the instrument can be levelled, and the bars can be

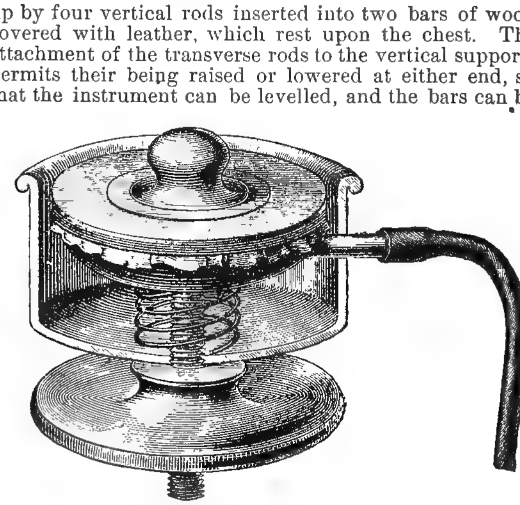


Fig. 3633.—Marey's Cardiograph, Receiving Apparatus of later form, 1875. (Gscheidlen.) Natural size.

separated to a width of nearly five inches, and adapted to a chest of any size or shape. The whole is fixed upon the chest by straps passed round the body.

Pond's and Dudgeon's sphygmographs have but a limited use as cardiographs, and give curves which are imperfect in some details.

For specimens of tracings obtained by various cardiographs, see article Pulse, Arterial, section Cardiogram.

Hydrosphygmographs. — The pulsating movement constituted by the increase and decrease of volume of an entire extremity, caused by the arterial diastole and systole, can be recorded by instruments combining the receiving apparatus of a plethysmograph with the registering mechanism of a transmission sphygmograph. Such are the hydrosphygmographs of François-Franck[14] (1876) and of Mosso[15] (1879). The latter, especially, affords curves very similar to those of the ordinary sphygmograph. The receiving apparatus of Mosso's instrument consists of a large glass cylinder filled with water, into which the forearm can be inserted, air-tight, through an opening closed by a rubber sleeve. The cylinder is suspended from above by a chain; it communicates by its smaller end with a reservoir of water which regulates the hydrostatic pressure; by another opening on top it is connected, by means of a flexible tube, with a Marey's tambour and lever. The curves thus obtained record the pulsatory changes in volume of the forearm. It is not to be expected that they agree perfectly with those obtained with the sphygmograph; the latter registers the changes taking place in the short piece of artery touched by the exploring button—practically one cross-section of the arterial system; the hydrosphygmograph registers the increments of volume of all sections of the arterial system of the forearm and hand at once, and since these increments do not take place at exactly the same time, a certain amount of fusing of details in the curve must result; that this fusion is, under ordinary circumstances, small, is explained by the high rate of transmission of the pulse-wave.

The instrument lends itself especially to investigations requiring continuous registration for hours, uniform external pressure upon the blood-vessels uninfluenced by their own changes of calibre, and immutable local conditions during changes in position and action of the body; and it permits the synchronous registration of curves of the heart's impulse, the carotids, the respiration, etc., by other instruments. It has yielded valuable results in the hands of its author.

The Recording Surface.—Some of the transmission instruments register upon a revolving drum, such as is used in the graphic instruments of the physiological laboratory (see Fig. 3631). Other sphygmographs are constructed for registering upon strips of smooth paper or glazed card-board, or upon slides of glass, smoked. Pond, I think, was the first to recommend slides of mica, useful by virtue of their lightness, and because, being very thin, they can be used as negatives for direct photographic reproduction.* Mica slides must be selected with care; those which are warped must be rejected, especially for Marey's instruments; in Pond's and Dudgeon's they are excellent substitutes for card-board. Paper and card-board answer well in the instruments which write with a loosely suspended needle; but the tracings cannot be multiplied as readily as when taken on transparent slides. Thin plate-glass is the best material for use in Marey's and in Keyt's sphygmographs, because of its smooth and level surface.

Glass and mica are best smoked in a large gas flame, which yields a very even coat of soot of any desired density. Paper must be smoked over a flame emitting less heat and more smoke, as an open petroleum flame, and this requires greater skill to obtain an even coating. In either case the coating of smoke should be as thin as is compatible with the purpose.

The curves are fixed by dipping the slides, of whatever material, into a thin, quickly drying varnish. Perhaps the most useful varnish is a concentrated solution of the best white shel-lac in alcohol. Some prefer the varnishes in use by photographers.

The method of writing with ink upon a glazed paper surface, by means of a pen or marker at the end of the lever, as in the older Marey instruments, has been abandoned, mainly because the friction involved in this method is far too great to give delicate traces.

In the foregoing account of instruments, no attempt at completeness has been made. Many other instruments have been invented; some have been confined to the physiological laboratory, or employed only by the inventors; others have been quickly abandoned. The sphygmographs in present use in medical practice, hospital or private, are chiefly the spring sphygmograph of Marey and its modifications by Burdon-Sanderson and by Mahomed, Grunmach's modification of the transmission sphygmograph of Meurisse and Mathieu, Pond's, and Dudgeon's.

Taking the Tracing.—To give in this place detailed directions for the application of each instrument were fruitless. The use of the sphygmograph is not easily learned, and skill in its application can be acquired only in conjunction with knowledge of the tracing and the pulse. The serious study of sphygmography is best begun with a Marey, Mahomed, or Burdon-Sanderson; although these are difficult to operate, they sooner teach the much more difficult art of recognizing whether or no the trace taken is a correct and adequate representation of the pulse explored.

In order to write a correct sphygmogram it is necessary (1) to explore the artery at the best possible point; (2) to exert just the requisite pressure upon it, neither too much nor too little; and (3) to let the lever write with the least possible friction.

1. The radial artery is best reached just before it crosses the end of the radius. Beginners often err, especially when using spring sphygmographs, in applying the exploring button higher up. At the point indicated the artery is most superficial, and rests upon a firm support; above this point it lies upon the pronator quadratus muscle and is embedded in abundant adipose tissue. In all sphygmographs the exploring mechanism and the means of fixing the instrument are constructed with special regard to this artery, but they do not all adjust themselves equally well even to this locality. In Marey's instrument, notably, the correct adjustment of the pressure upon the artery is sometimes impossible with the mechanical means provided; the best tracings are often obtained by holding the lower end of the instrument in the fingers. With Dudgeon's sphygmograph the exact spot and the proper pressure are more easily found, most easily with Pond's, and with the movable bases of transmission sphygmographs. Care must be taken to place the button or explorer exactly over the artery; if the button lies to one side of it, the curve is stunted in its details; if it slips off and lies alongside the artery, there often results a so-called negative curve.

The arm should be slightly flexed at the elbow, the hand supinated and fully, but not forcibly, extended at the wrist. A rest for the hand, as the wedge-shaped cushion of Mahomed, is often useful in connection with the spring sphygmographs, but not indispensable. The rest provided for the original Pond's was a useless encumbrance, and has been abandoned.

2. Next to the most available locality, the degree of pressure is of greatest importance. The exploring button or base should come into such (mediate) contact with the arterial walls that it must follow their movements closely. If too far removed (too lightly applied), it receives the impulse of the artery too feebly or too late, and fails to record them in proper extent or time; if pressed too forcibly upon the artery, the expansion of the latter is diminished and delayed: in either case the curve is too small and otherwise deformed. Figs. 3634 to 3636 afford examples; also Fig. 3637, *e* and *f*.

With insufficient pressure, the curve is small and inexpressive, and the secondary waves are ill developed (Figs. 3634, *a*; 3636, *a*.) As the pressure is increased the secondary events become more pronounced and characteristic, and the curve grows higher. With a pressure exactly

* Most of the tracings illustrating this article, and the article Pulse, were taken on mica; some on glass.

suited to the pulse, the details of the curve are most perfect, and the secondary waves, especially the dicrotic, most distinctly delineated (Figs. 3634, *b*; 3635, *b*; 3636, *b*). Still increasing the pressure, we see the curve diminish in amplitude, the up-stroke being shortened (expressing a celerity greater than the actual); but the apex is still sharp, and the predicrotic wave well expressed, while the dicrotic elevation becomes smaller (Fig. 3635, *c*,

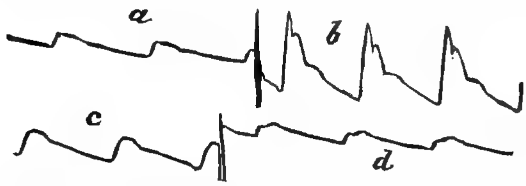


FIG. 3634.—Radial Pulse of Healthy Man, aged fifty. Dudgeon's. *a*, Pressure, 1 oz.; *b*, 3 oz.; *c*, 4 oz.; *d*, 5 oz., the instrument meanwhile remaining *in situ*.

d). With still increasing pressure the curve becomes much smaller, the upstroke short, the first secondary wave is much enlarged, and the dicrotic wave disappears (Fig. 3634, *c*, *d*). The resulting trace is that of a very hard, even anacrotic curve (Figs. 3634, *d*; 3636, *c*), such as only highly atheromatous arteries could truly give. Still stronger pressure finally suppresses the pulse altogether.

The evident importance of this point, and the desire, by means of the pressure found necessary, upon trial, to

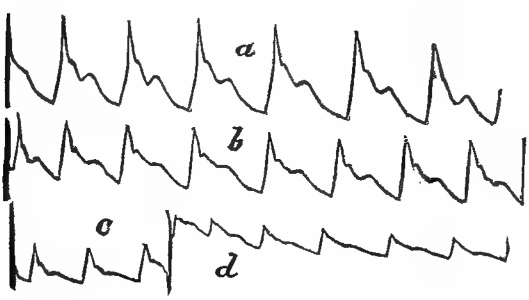


FIG. 3635.—Healthy Boy, aged six. Dudgeon's. *a*, Pressure, 2 oz.: *b*, 3 oz.; *c*, 4 oz.; *d*, 5 oz.

evoke the most perfect curve, to estimate the blood-pressure within the living artery, has led sphygmographers to devise means not only for varying, but for expressing the pressure of the instrument in numbers. This object has been accomplished only in those pulse-writers which exert their pressure by weights instead of springs, as in Landois's angiograph—an instrument of great scientific accuracy—and in Keyt's sphygmograph by means of the manometric tube. But even in this case the weights indicate only the pressure upon the skin, not that upon the

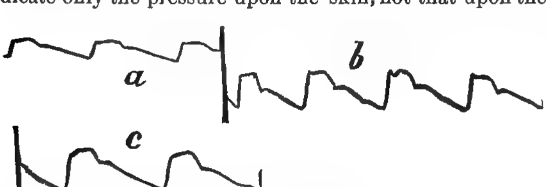


FIG. 3636.—Woman, aged forty-eight. Dudgeon's. *a*, Pressure, 1½ oz.; *b*, 2½ oz.; *c*, 3 oz.

artery, which must be less than the former, by the variable amounts of elastic resistance of the intervening skin, fascia, and neighboring tendons. This source of error, and the impossibility of estimating the force exerted in fastening the sphygmograph upon the wrist, has made all attempts at measuring the pressure with other instruments illusory. The devices to this end of Burdon-Sanderson and of Mahomed furnish numbers of only approximate value, useful when the pressure is varied while the instrument remains *in situ*, but not comparable with observations at different times or on different arteries—not at all comparable with the numbers expressing the pressure in other instruments.

Sphygmographs in which the pressure is controlled by the hand alone, as in Pond's, are most easily adjusted, and the pressure can be more evenly applied in this way than would seem possible.

Even if the degree of pressure could be accurately known, it would still give no correct information as to the blood-pressure; the form of the pulse-curve assists in judging of the comparative degree of tension of the artery; but accuracy in determining the compressibility of the pulse must be sought by aid of other instruments, such as Waldenburg's Pulsuhr or Basch's sphygmomanometer.

3. When the lever of the instrument meets with too much friction the curve is altered in the same direction as when excessive pressure is used; it loses in delicacy, the minor events are obliterated, and the apex is apt to be blunted or flattened. Hence it is essential that the recording surface be very smooth, and smoked only just enough to make the trace distinct. For the same reason, the method of writing with an inked style upon a glazed paper has been almost discarded. Moreover, the lever should not bear too firmly upon the surface.

In judging of the adequacy of a curve, two points are of special importance: the apex should be sharp, and there should be no evidence of vibrations due to inertia of the instrument itself. A curve with a rounded, blunt, or truncated apex is to be suspected until all source of error is eliminated. This defect is common in the tracings by the spring sphygmographs, and is owing either to excessive pressure (too hard a spring, as in many of Marey's instruments) or to undue friction in the writing apparatus. Vibrations by inertia, exaggerated excursions of the needle, are apt to deform the curves by Pond's and Dudgeon's instruments. Not only may evident and avoidable monstrosities of curves * result in this manner, but there is a general tendency to exaggerations of certain events in the curve.† The fall of the lever is apt to be too rapid and too sudden, deepening the depressions preceding the secondary waves, and hence also increasing the size of the latter. (Compare Fig. 3637, *b*, *c*). These sphygmographs produce dicrotism too easily, with lower fever-temperatures, than the spring sphygmographs do, and generally their curves have the look of low tension. On the other hand, the frequently exaggerated predicrotic wave sometimes gives the appearance of higher tension than is found with other instruments.‡ This error in interpretation is in a measure guarded against by comparing the relative height and position of the predicrotic with the dicrotic wave.

It is evident, therefore, that the instruments described differ greatly in the two practically important respects of (1) facility of application and (2) accuracy of results. Unfortunately, those which excel in the one are most apt to fail in the other. In ease of handling, Pond's and Dudgeon's sphygmographs take the first rank, and the transmission instruments with movable bases, especially Keyt's, are likewise easy of adjustment. Among the spring sphygmographs, Mahomed's and Burdon-Sanderson's are more readily applied than Marey's own. For

* Broadbent (British Medical Journal, March 26, 1887, i., p. 657) gives a curve to illustrate the vagaries of Dudgeon's sphygmograph, but which shows, rather, the inexperience of the operator who would seriously present it as the curve expressing the movements of the artery. Bad curves can be taken with a Marey as well, erring mostly in an opposite direction, as the student can best learn from the excellent article "*Ueber fehlerhaftes Pulszeichnen*," by Wolff, in the Prager Vierteljahrsschrift f. prakt. Heilk., 1871.

† A glance at the curves taken with an Edwards sphygmograph (modification of Pond's), and published by Dr. H. R. Hopkins (Medical Press of Western New York, November, 1885, pp. 7. 9, 10, 12), will illustrate this point; some of these curves reproduce only the vibrations of the instrument itself, *e.g.*, Fig. 5 (M. S.), 4 (B.), and 6 (E. H.).

‡ In Guy's Hospital Reports, 1881, p. 337, Mahomed reproduces a tracing by Pond's to show "very high tension," which by no means shows it. He was evidently led into error by comparing Pond's curves with those of his own sphygmograph, without due allowance for inherent differences in the action of the two instruments.

his angiograph Landois himself does not claim clinical convenience. In accuracy of results, however, the sphygmographs named rank in nearly inverse order. Curves obtained with different instruments in different cases cannot be directly compared, no matter how perfect of their kind they may be. Those written with Marey's spring sphygmograph are universally accepted as reproducing most exactly the movements of the arterial wall, and to them all others must be referred. The use of Pond's and Dudgeon's sphygmographs, so thoroughly convenient for every-day practice, can be recommended only to those who are familiar with the working of the spring sphygmographs; their convenience is offset by the danger of misinterpretation from neglecting to allow for the inherent defects of the instruments.

For illustrations of the tracings afforded by a number of sphygmographs and cardiographs the reader is re-

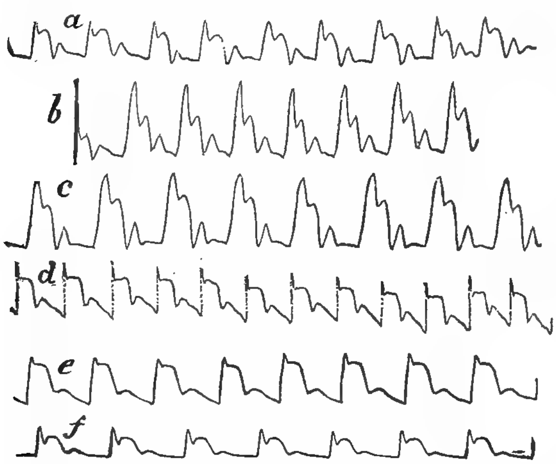


FIG. 3637.—Man, aged fifty-three to fifty-four. Moderate Hypertrophy of the Heart. Subject to infrequent attacks of angina pectoris. *a*, May, 1886, Pond's; *b*, June, 1886, Pond's; *c*, August, 1886, Pond's; *d*, October, 1886, Marey's; *e* and *f*, March, 1887, Dudgeon's. Pressure, 2¼ oz. and 4½ oz., respectively. (The latter pressure is too great.)

ferred to the article Pulse, Arterial, and to the series of Fig. 3637, which reproduces the pulse-curves in the case of one individual, in fair general health, taken at different times under varying conditions, by Pond's, Marey's, and Dudgeon's sphygmographs. *G. Baumgarten.*

1 Landois: Lehre vom Arterienpuls, Berlin, 1872, p. 49, where the reader will find a résumé of Mach's experimental criticism, with references.
2 Mach: Sitzungsberichte d. k. k. Akademie der Wissensch. zu Wien, 1863. 3 Béhier: Bulletin de l'Acad. de Médecine, Paris, 1868.
4 Burdon-Sanderson: Handbook of the Sphygmograph, p. 7. London, 1867. Handbook of the Physiological Laboratory, pp. 229, 230. Philad., 1873. 5 Mahomed: Med. Times and Gazette, 1872.
6 Baker: Brit. Med. Journal, 1867, p. 604.
7 Landois: *loc. cit.*,[1] p. 70.
8 Sommerbrodt: Ein neuer Sphygmograph. Breslau, 1876.
9 Figured in Ozanam: La Circulation et le Pouls, p. 417. Paris, 1886.
10 Keyt: Sphygmography and Cardiography. New York and London, 1887. 11 Ozanam: *loc. cit.*,[9] p. 432 et seq.
12 Hopkins: Medical Press of Western New York, November, 1885, p. 5.
13 Galabin: Medico-Chirurgical Transactions, vol. lviii., p. 359. Figured and described, also, in Bramwell: Diseases of the Heart, p. 753. New York, 1884.
14 François-Franck: Travaux du Laboratoire de M. Marey. Paris, 1876. 15 Mosso: Die Diagnostik des Pulses. Leipzig, 1879.

SPINAL ABSCESS. Usually in the course of caries of the spine, or Pott's disease, suppuration takes place. To the collections of pus which result may be given the generic term "spinal abscess." Surgeons, however, have been long in the habit of naming these collections after the regions in or near which they first make their appearance on the surface. Hence the terms cervical or post-pharyngeal (retro-pharyngeal), dorsal, lumbar, iliac, psoas abscess, etc., depending on the locality diseased or invaded.

FORMATION OF SPINAL ABSCESS.—As in caries or ulceration of bone elsewhere, granulations rapidly spring up in the affected vertebra, raising the periosteum, which in turn becomes much thickened and vascular, and is itself often penetrated by the same granulations. Thus not only is pus formed, but at the same time the soft parts outside the periosteum become gradually inflamed, infiltrated, and thickened, and ultimately constitute the chief boundary wall of the purulent collection. Where the caries originates in the centre of one of the vertebral bodies these changes progress very slowly, and adjoining vertebræ may become invaded before pus appears external to the bone. Indeed, the abscess may never become visible (caries sicca), remaining within the limits of the bone. To this variety the term "vertebral abscess" has been given. The tendency, however, is to the formation of large collections, which usually take a downward course, limited only by the resistance of the soft parts. The pus resulting is at first usually curdy, but later becomes more homogeneous, though seldom laudable. Bone-dust and fragments of necrosed bone are also occasionally present.

The occurrence of spinal abscess is always a serious complication of Pott's disease, and is probably the most common cause of death. It has been noticed also that the more circuitous the route taken by the pus, the more serious are the consequences likely to be.

The variety of spinal abscess will depend on the region affected with caries, on the resistance offered to the pus as it leaves the diseased bone, and on the route subsequently taken to reach the surface of the body.

While caries of the vertebræ is by far the most frequent cause of spinal abscess, it is well to mention that collections of pus due to other causes are occasionally found in the immediate vicinity of the spinal column, and may receive the same name. Thus we occasionally find abscesses in the cervical region due to tubercular and syphilitic ulcerations about the pharynx, while a more acute form is now and then met with as a complication of acute pharyngitis and quinsy. So psoas abscess may occur quite independently of disease of the vertebræ.

CERVICAL ABSCESS, termed also *post-pharyngeal* and *retro-pharyngeal abscess.*—This usually results from disease of one or more of the cervical vertebræ, and is often the first indication of caries. It is, however, not invariably due to this cause. The writer has seen retro-pharyngeal abscess, evidently following tonsillitis or pharyngitis, in children, where there were restrained movement of the neck, retraction of the head, and other signs of caries. The abscesses were evacuated behind the sterno-mastoid muscle, when all symptoms suddenly disappeared and complete recovery followed. Usually when the disease is confined to the anterior or lateral surface of the bodies of the vertebræ, a soft, fluctuating, and somewhat œdematous swelling is to be seen and felt bulging forward on the posterior wall of the pharynx. This may increase to such an extent as to interfere with deglutition, and even to cause troublesome and alarming dyspnœa. Purulent collections from cervical disease, however, more frequently proceed in a lateral or postero-lateral direction, between the longus colli and scaleni muscles, first appearing in the posterior triangle of the neck, behind the sterno-cleido-mastoid muscle. In very exceptional cases cervical abscess points posteriorly near the ligamentum nuchæ, and still more rarely the pus gravitates downward into the posterior mediastinum, whence it may enter the pleura or pericardium. Cervical abscess has likewise been known to penetrate the œsophagus and trachea, and in one case reported, first appeared in the axilla.

The *diagnosis* of abscess from cervical disease is seldom difficult, if due attention be paid to the signs and symptoms of bone disease invariably present, namely, stiffness of the neck, with limited movement of the head, deformity, and increased pain on pressure over the cervical spine.

The *dangers* of cervical abscess are chiefly dyspnœa and suffocation, the latter from sudden bursting of the collection, especially during sleep, and the entry of pus into the air-passages. Gautier collected 97 cases, of which

41 proved fatal, but this is an exceptionally large mortality, and it is probable that not more than from fifteen to twenty per cent. terminate in death.

The *treatment* of all the forms of spinal abscess will be described further on in this article.

Dorsal Abscess.—By this is meant usually a collection of pus, the result of caries of the dorsal vertebræ, which has passed backward between, or external to, the transverse processes, and opened on the back. The collection in this case may be part only of a large psoas abscess, some of the pus gravitating backward in consequence of long confinement of the patient in the recumbent position. Dorsal abscess usually first appears on one side of the spine, its inner margin being often not more than an inch or two from the vertebral column. The pus occasionally passes outward along the intercostal muscles, and points in the lateral region of the thorax or abdomen, or near the middle line in front.

Dorsal abscess is frequently mistaken for fatty tumor, chiefly on account of its smooth outline and the absence of inflammatory symptoms. Besides, this is a favorite situation for lipoma. The aspirating needle should be resorted to in all cases of doubt. From abscess, the result of a necrosed rib, and from a pointing empyema the diagnosis should be made with ease by due attention to the symptoms.

It is remarkable, considering the proximity of the pleural cavity, how seldom abscess, the result of caries of the thoracic vertebræ, encroaches on that cavity. Cases are reported, however, in which this cavity has become the receptacle for a dorsal abscess, and fatal pleurisy has resulted from this cause. Agnew[1] refers to a case in which, through inflammatory adhesion, the two layers of the pleura, with the lung, united to the sac of the abscess, and through ulceration the purulent accumulation opened into one of the bronchial tubes and was discharged by the mouth.

Psoas Abscess.—This is the commonest variety of abscess, resulting from vertebral disease. It may follow disease in any part of the dorsal or lumbar portions of the spine, but is most frequently met with in cases where the lower dorsal or upper lumbar regions are affected. The pus, guided by the thickened periosteum and soft parts, reaches the diaphragm, where it arches over the lumbar muscles, and forcing a passage beneath the internal arcuate ligament, enters the substance of the psoas magnus muscle, along which it passes to its insertion beneath Poupart's ligament, and presents in Scarpa's space. Thus the entire psoas sheath may become converted into a bag of pus, the muscle being removed by a process of absorption. Bifurcation of the abscess sac has been known to take place high up, the pus descending in both psoas muscles forming a double psoas abscess; or two abscesses may form independently at the source of the disease. The latter variety, however, is very rare.

The pus may leave the psoas sheath at any part in the course of the abscess, proceeding sometimes in odd directions. Thus it may pass forward and find its way along any of the planes of areolar tissue in the abdominal wall, travelling between the transversalis muscle and fascia, or, perforating the fascia, may get between the latter and the peritoneum. Again, taking a more superficial course it may point in front, perhaps in the position of the external abdominal ring, closely simulating inguinal hernia. Or a portion of the abscess may pass along the sacrum by the side of the rectum and present in the perineum, like an ischio-rectal abscess. Or, finally, leaving the pelvis by the great sacro-sciatic notch, either above or below the pyriformis muscle, it may appear in the gluteal region (gluteal abscess), and thence pass down the thigh in the course of the sciatic nerve. The small intestine, colon, rectum, and bladder have all been penetrated by the pus from psoas abscess. Broca[2] reports a rare form of psoas abscess where the pus entered the hip-joint, penetrating the anterior part of the capsule. In its passage through the iliac fossa it is not uncommon for a psoas abscess to be arrested in its progress and form a prominent swelling. It is then termed "iliac abscess."

Below Poupart's ligament a psoas abscess generally takes an independent course, either spreading over the front of the thigh, or, guided by the sartorius muscle and the fascia, passes down the inner aspect and back of the limb, until, as in a case reported by Erichsen,[3] it may reach even to the heel.

Diagnosis.—This is usually an easy task, providing always that a rigid investigation has been made regarding the condition of the spine. It is true, psoas abscess may make its appearance before any noticeable change has taken place in the contour of the spine, but there will be present, almost invariably, a feeling of stiffness of the back, and a persistent pain in one locality. As before intimated, it is possible to have suppuration within the sheath of the psoas muscle as the result of sprain or inflammation of the muscle itself (psoitis), quite independently of disease of the vertebræ. Here there will be an absence of all the ordinary signs of Pott's disease, and thorough evacuation of the abscess should be followed by speedy cure. The simple form is found most frequently in adults.

Among the conditions met with in the vicinity of Poupart's ligament, with which psoas abscess might be confounded, are the following: Large buboes or glandular abscesses, suppuration from hip-joint disease (in those cases where the bursa of the conjoined tendon of the psoas and iliacus muscles communicates directly with the hip-joint), hernia, serous cysts, fatty tumors, pus from an empyema which has found its way into the psoas sheath, aneurism, and phantom tumors in hysterical females. While the abscess is still in the iliac fossa there may be some difficulty in diagnosing it from peri-cæcal abscess (on the right side only), perinephritic abscess, fluctuating renal tumors, and iliac abscess, the result of disease of the sacro-iliac joint or of the pelvic bones. There is, besides, the possibility of an abdominal or iliac aneurism, communicating with the sheath of the psoas muscle and forming a diffuse, non-pulsating extravasation. The pain from erosion of the vertebræ in such a case may easily be mistaken for the pain of Pott's disease.

It would be impossible within the limits of this article to give the diagnostic differences between psoas abscess and all the conditions above enumerated. It is simply necessary to state that in the latter, almost without exception, there will be an absence of stiffness and pain in the dorsal and lumbar spine; whereas in none but abscess accompanying Pott's disease will there be any excurvation.

Lumbar Abscess.—This usually results from disease of the lumbar spine, although it is possible to have this variety of spinal abscess from disease in the dorsal region. Here the pus, whether it comes from a psoas abscess, or directly from caries of the lumbar vertebræ, passes to the outer edge of the quadratus lumborum muscle, and projects posteriorly in the space between the last rib and the crest of the ilium. Like all cold abscesses in the back, this may readily be mistaken for fatty tumor, but attention to the points referred to in connection with dorsal abscess should obviate the possibility of such a mistake.

General Observations. — Spinal abscess seldom makes its appearance for many months after the disease in the vertebræ has begun. In fact, many years have been known to elapse before suppuration was noticed. Such cases are probably examples of what Paget[4] terms "residual abscess," meaning an old abscess cavity, in which from some cause, as ill-health or injury, a fresh inflammation, and suppuration, have been suddenly lighted up. On the other hand, abscess may be the first indication of the presence of caries. As might be imagined, the more acute the disease in the bone, and the greater the constitutional disturbance, the more rapidly does abscess form and make its appearance on the surface. Again, we meet with cases where great excurvation has occurred without any evidence of suppuration.

Prognosis of Spinal Abscess.—The larger the abscess, and the more extensive the ground traversed by the pus, the more serious will be the prognosis. The most favorable cases are those in which the abscess opens close

to the seat of disease. The greatest of the primary dangers in connection with suppuration are exhaustion and septicæmia. Secondary dangers are inflammation of serous membranes, due to the invasion of cavities by the pus; hæmorrhage from ulceration into a large artery or vein; suffocation (in cervical abscess only), and amyloid disease of the liver and kidneys. Many of the deaths from Pott's disease occur soon after the abscess is opened. Thus Michel records a series of 28 cases where, in ten instances, death followed the evacuation of the abscess within twenty days. The presence or absence of hereditary predisposition to struma, the social conditions and hygienic surroundings of the patient, and the quality of surgical skill employed in the case, will be found to influence the prognosis in a marked degree.

TREATMENT OF SPINAL ABSCESS.—Up to a very recent date there was a general consensus of opinion among surgeons that spinal abscess should not be opened hastily. This advice should still be followed in cases where suppuration appears to be arrested, and absorption or caseation is likely to supervene. As a rule, however, where the collection is large, and evidently increasing, early interference is in order. Since Lister began to teach surgeons how to take care of these abscesses the old dread of interfering with them has ceased to exist.

Cervical Abscess.—Here, perhaps, more than in any other form, should the practice of early opening prevail, lest, bursting unexpectedly, the pus might be drawn into the larynx and produce suffocation.

Opening through the Mouth.—Should the abscess point in the pharynx more markedly than elsewhere, one often has no alternative but to evacuate it through the mouth, by means of a trocar or of a guarded bistoury. The patient should be placed in the sitting position, with the head thrown well forward. An anæsthetic is not usually required, excepting perhaps in the case of a very rebellious child. The mouth should be held open by means of some simple gag, which can be withdrawn simultaneously with the bistoury, so as not to interfere with the action of the palatal and pharyngeal muscles in their endeavor to project the pus forward. The forefinger of the left hand may be used to depress the tongue and push it backward, thus forcing the epiglottis to close. The incision should be made as nearly as possible in the middle line, and directly upward. When the abscess is pointing, the sharpened finger-nail of the surgeon may be employed to open it, instead of the bistoury. Some antiseptic mouth-wash, containing carbolic acid, iodine, or Condy's fluid, should be used freely as a gargle, as well as for injecting the abscess-cavity.

Opening in the Neck.—When the collection tends to point laterally it will usually first be detected behind the sterno-mastoid muscle, on a level with the angle of the jaw. Here, when practicable, cervical abscess should always be opened, chiefly because of the comparative ease with which it may be kept aseptic. Professor Chiene, of Edinburgh, was one of the first surgeons to advocate this method of treating post-pharyngeal abscess. He recommends a free incision through skin, superficial fascia, and platysma muscle, carried along the posterior border of the sterno-mastoid. Then a small opening is made through the deep fascia, into which a director is pushed onward until pus is reached. The deeper parts of the incision are opened up by means of dressing-forceps, after Hilton's method. A drainage-tube is then introduced, and throughout the strictest antiseptic precautions are taken. There can be no objection to the use of the aspirator here, as in any variety of spinal abscess, providing the purulent collection can be accurately located in the neck. When the abscess is undoubtedly due to caries, the head and neck should meanwhile be well supported, either by means of sand-bags or by a leather collar. The writer employed plaster-of-Paris in a memorable case[5] of caries of the upper cervical vertebræ, with post-pharyngeal abscess, in which the weight of the plaster caused partial dislocation of one of the diseased vertebræ and alarming asphyxia, with almost complete paralysis of sensation and motion. The patient died of exhaustion in about four weeks.

In all varieties of spinal abscess the bag of pus acts as a sort of splint to the crumbling vertebræ; hence, before removing the purulent collection by operation, means should be taken to provide a substitute of some kind for the support about to be withdrawn. Sayre's plaster dressing (with the jury-mast in cases of cervical and upper dorsal disease) will be found one of the most convenient methods for carrying out this indication.

Dorsal and Lumbar Abscess.—These need not be interfered with until they show signs of rapid enlargement. The aspirator should first be brought into requisition. The needle should not be thrust into the summit of the abscess, but introduced at a considerable distance from the border, so as to traverse an inch or two of healthy tissue before entering the abscess-cavity. In this way leakage and the admission of air are effectually prevented. A firm compress and bandage should afterward be applied over the situation of the empty abscess. Aspiration may be repeated three or four times, after which, if ineffectual, or if the needle becomes blocked with curdy matter, a free, dependent opening should be made and a large drain introduced. Every means should be adopted to keep the cavity aseptic. The late Mr. Callender's method of hyperdistention with weak carbolic or boracic solution may be practised with benefit here.

Psoas Abscess.—There can be no objection to one or two aspirations in this variety of abscess, although it is well not to evacuate the contents completely at one time, as alarming syncope has been known to follow the sudden removal of large collections of this kind, doubtless from disturbance of the circulation. Some pains should be taken to make the valvular puncture above referred to.

There are few surgical conditions in which Lister's antiseptic precautions are so urgently called for as in the treatment of psoas abscess by incision. It is a well-known fact that, by the older methods, death from exhaustion or septic troubles almost invariably followed the opening of this variety of abscess. Paget has declared that he could not recall to mind a single case of extensive psoas abscess in which recovery followed the older plans of treatment. Should the abscess have, unfortunately, opened before surgical aid has been sought, much may still be done by injecting a solution of chloride of zinc (one per cent.), or of bichloride of mercury (1 to 5,000), followed by injections of warm water.

Opening below Poupart's Ligament.—When the abscess points below Poupart's ligament, the incision may be made at the most dependent point, and simply large enough to admit a good-sized drainage-tube, every precaution being taken to prevent sepsis. The part should be thoroughly washed and shaved, and the spray or continuous irrigation employed while the wound remains uncovered. To encourage free drainage, the patient should be kept in a sitting position, or, where the condition will justify it, he may be allowed to move about for a short time each day.

Opening above Poupart's Ligament.—Where the abscess is still intra-abdominal it may with advantage be opened above the ligament. An incision is made as if for ligature of the external iliac artery. The abscess-sac being reached, it is opened by scratching through it with a director, followed by dressing-forceps. Lister, who was probably the first to practise this method, claims for it that the abscess-cavity is by so much shortened, while the risks of putrefaction are considerably lessened. In fact, in cases where the abscess has already extended below Poupart's ligament the method of incision above described may with advantage be employed.

Operation in the Loin.—Professor Chiene, of Edinburgh; Mr. Frederick Treves, of London; and Dr. Norman Chavasse, of Birmingham, recorded almost simultaneously the successful treatment of psoas abscess by incision in the loin. Dr. Chavasse[6] describes the operation as performed by him, briefly, as follows: "An incision is made immediately above the crest of the ilium, commencing at the edge of the erector spinæ muscle, and carried three or four inches transversely outward toward the anterior superior spine. The various structures are

divided, as in colotomy, till the quadratus lumborum muscle is reached. The forefinger should then be passed downward and forward on the iliacus muscle till the tense and distended psoas sheath is detected. A scalpel should then be carried along the finger and the abscess incised, the opening being enlarged by dressing-forceps. A drainage-tube should be introduced and the wound treated antiseptically." In this way the anterior surfaces of the bodies of all the lumbar and of the last dorsal vertebræ can be reached from the loin and thoroughly examined, while at the same time any particles of necrosed bone can be removed. The most dependent drainage possible is thus procured. Treves reports three cases treated in this way. In one he removed forty ounces of pus and a large sequestrum from the first lumbar vertebra. In another, where the abscess had pointed in the thigh, he passed a tube from the origin of the psoas muscle to its insertion, thus draining the entire abscess-cavity. The third case succumbed to amyloid disease soon after the operation.

Mr. Edmund Owen strongly advocates the early opening of psoas abscess. He recommends a free anterior as well as posterior opening, and a thorough washing out of the cavity. He says:[7] "The first opening I make close above the outer end of Poupart's ligament, using the scalpel until about an inch of the length of the fibres of the aponeurosis of the external oblique has been exposed. I then scratch through the fleshy attachment of the internal oblique and transversalis, and, keeping well below the level of the peritoneum, thrust the director into the swelling. Pus escapes, and the opening is enlarged by the dressing-forceps and the finger. A stiff probe is then passed through the abscess-cavity, and made to project beneath the skin on the outer side of the erector spinæ. With this as a guide, a counter-opening is made in the loin. The large cavity is then flushed perfectly clean with a warm antiseptic solution, and a drainage-tube of the size of a penholder is laid through the chasm for a few days, being afterward replaced by a silk thread." For a dressing Owen prefers pads of wood-wool and picked oakum inclosed in gauze bags. He irrigates with warm iodine-water decolorized by carbolic acid. He considers the sublimate solution highly dangerous, having had a sad experience in one case, where the use of a 1 to 1,000 solution caused the death, within four hours, of a child six years of age.

In conclusion, the writer would be disposed to urge the early and careful aspiration of psoas abscess, repeating this at least twice. Then, should a subsequent operation become necessary, he would be disposed to recommend Owen's method, above described, as being both safe and easy of execution. For purposes of irrigation the warm solution of boracic acid is preferred, being sufficiently antiseptic and free from toxic properties. As a dressing, a powder composed of equal parts of boracic acid and naphthalin or hydronaphthol may be dusted freely over the wounds and into the drainage-tube, the whole being enveloped in a large pad of sublimated jute.

T. G. Roddick.

1 Agnew's Surgery, p. 882.
2 Bull. de la Soc. Anat., tome xxvi., p. 406.
3 Science and Art of Surgery, vol. ii., p. 242.
4 Lectures and Essays, p. 310.
5 Montreal General Hospital Reports, vol. i., p. 141.
6 Lancet, December 29, 1883, p. 1119.
7 Brit. Med. Journal, April 23, 1887, p. 869.

SPINAL CORD, DIAGNOSIS OF LOCAL LESIONS IN THE. In diseases of the spinal cord it is usual for the lesion to involve a portion only of the organ. It is true that in general myelitis the entire spinal cord may finally become affected, but even in this disease it is the rule for the lesion to invade one part after another rather than for it to begin at once in the entire length of the cord. And it is well known that in infantile paralysis, in progressive muscular atrophy, in locomotor ataxia, in spastic paraplegia, and in ataxic paraplegia, the lesion is strictly defined in its extent, being limited so exactly to a set of nerve-cells, or of nerve-tracts of a single function, that for these affections the term "system-diseases" has been coined. Furthermore, from its peculiar form—that of a long but small organ—and from its location—within the spinal column—the spinal cord is liable to become the seat of disease at some particular level rather than in its entire length. Thus pressure from injuries of the vertebræ, or from the effects of Pott's disease, or by tumors; or destruction by wounds, or by intraspinal hæmorrhage, will affect only a small segment of the entire cylinder.

It is evident, therefore, that in diseases of the spinal cord local lesions are the rule, and that the symptoms will vary greatly, and will depend entirely upon the particular portion of the organ which is involved.

Hence, in the diagnosis of diseases of the spinal cord it is necessary to determine the situation of the lesion

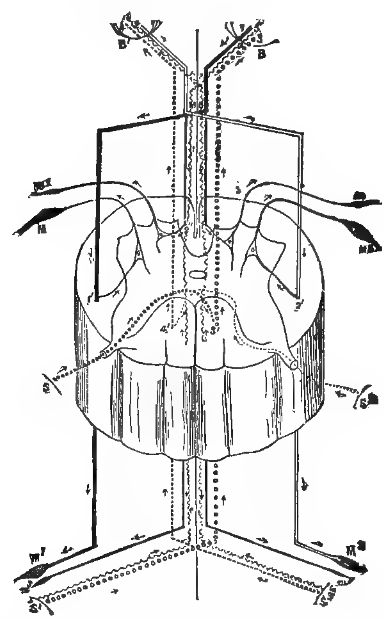


FIG. 3638.—Diagrammatic Representation of the Spinal Segment as a Spinal Centre and as a Conducting Medium. (Bramwell.) B, Right, B′, left, hemispheres of the brain; M O, medulla oblongata; 1, motor tract from right hemisphere: at M O it divides; the larger subdivision decussates, passes down the lateral column of the opposite side of the cord, and supplies the muscular fibres M and M′ on the left side of the body; at 1′ the supply to M is given off; the smaller subdivision does not decussate, but passes down the anterior column, and supplies the muscles m and m′ on the same (right) side of the body; 2, motor tract from left hemisphere; it supplies muscles M^2 and M^3 on the right side of the body, and muscles m^2 and m^3 on the left side of the body; S, S′, sensitive areas on the left side of the body; 3′, 3, the main sensory tract from the left side of the body; it passes into the gray matter of the segment, then decussates, and passes up the right half of the spinal cord in the posterior columns, and thence to the right hemisphere of the brain; S^2, S^3, sensitive areas on the right side of the body; 4′, 4, the main sensory tract from the right side of the body, up the left half of the cord to the left hemisphere of the brain; 5, 6, tract of muscular sense from the legs, passing up upon the same side of the spinal cord in which it enters, in the column of Goll, decussating at the medulla, above the motor decussation, that from the left side of the body (5) going to the right hemisphere, that from the right side (6) to the left hemisphere; the arrows indicate the direction of the nerve-currents.

producing the symptoms. And this is by no means as simple a matter as might be supposed. For the spinal cord is a long, cylindrical organ, made up of numerous segments, each of which not only has a function of its own, but also bears an important part in relation to the functions of other segments. Each segment of the cord consists of a mass of gray matter, surrounded by a series of white tracts, from which passes out a pair of spinal nerves. In some of the lowest order of vertebrata the comparative independence of each segment is indicated by the fact that the spinal cord consists of a series of bulbous enlargements joined together by only a few connecting fibres. And even in man there are some evi-

dences that the functions of each segment of the cord are independent of all others. But in the higher vertebrata the various segments are closely united to one another, and are also connected with the brain, which controls them all, by means of the white tracts surrounding the gray matter. Hence, in addition to its own special function as a nervous centre, each segment has functions of transmission of impulses to adjacent segments and to distant parts of the nervous system. Therefore, in dealing with local lesions in the spinal cord, the first point to determine is whether the lesion involves the nerve-centres of a single segment, or the tracts which pass through that segment to other centres. In the first case, when the gray matter of a single segment is affected, the symptoms are limited in extent and in number, consisting of localized paralysis, limited anæsthesia, loss of certain reflexes, disturbance of certain automatic actions, and local vaso-motor and trophic disturbances. In the second case, when the white matter of a single segment is affected, the symptoms are widespread and numerous, consisting of partial or complete paraplegia, anæsthesia of the lower half, or even of the entire body, loss of control over reflex and automatic activity, and extensive vascular and trophic changes. And when both gray and white matter of a single segment are totally involved, there will be a combination of local and general symptoms, the distribution and extent of which will depend wholly upon the particular level of the segment of the cord which is affected. It is therefore evident that the first step in the diagnosis of local lesions of the spinal cord is the determination of the functions of the various segments, and of the various tracts which pass through them.

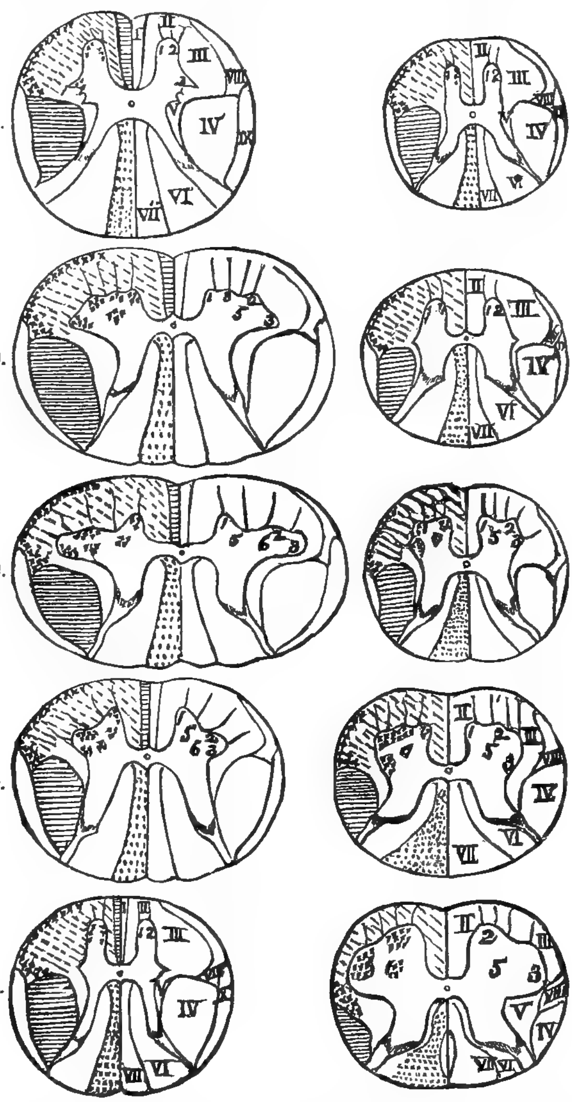


FIG. 3639.—Diagrams of Transverse Sections of the Spinal Cord at Different Levels; the level at each section is indicated by the number opposite to it. 1 to 6, Groups of cells in the anterior horns: 1, inner; 2, antero-lateral; 3, postero-lateral; 4, anterior; 5, median; 6, central. I to IX, Columns of the cord: I, Direct or anterior pyramidal tract, or column of Türck; II, anterior, and III, lateral ground-fibres, separated by exit of anterior nerve-roots; IV, crossed or lateral pyramidal tract; V, lateral limiting layer; VI, postero-external tract, or column of Burdach; VII, postero-internal tract, or column of Goll; VIII, antero-lateral ascending tract; IX, direct cerebellar column.

I. THE FUNCTIONS OF THE SEGMENTS OF THE SPINAL CORD.—Each segment of the spinal cord consists of that portion of the entire organ giving origin to one pair of spinal nerves (see Fig. 3638). There are, therefore, thirty-one segments in the human cord. There is no natural division between adjacent segments, but if a cord with its nerves be carefully removed, there will be no difficulty in cutting it up into segments, each of which will receive two afferent and give off two efferent nerves. Each segment is made up of two symmetrical halves, naturally separated by the anterior fissure and posterior septum, but joined by a commissure.

The afferent or sensory nerves enter the posterior surface of the segment, and, passing through the white matter, end in the gray. The efferent or motor nerves pass out from the anterior surface of the segment, having their origin in the anterior gray horn, and traversing the white matter bordering these horns.

A. The Gray Matter.—The size and shape of the area of gray matter, seen in horizontal section of the cord, differ in almost every segment, the difference between adjacent segments being more marked in the cervical and lumbar enlargements than in the dorsal region. The shape of the area of gray matter in the dorsal region resembles that of the letter H, and, accordingly, anatomists describe two lateral halves with a central gray commissure between them, and in each half an anterior and a posterior horn. In the enlargements of the cord the mass of the horns is much larger than in the dorsal region, and the shape varies in each segment. The amount of gray matter in any segment depends upon the number of cells in the anterior and posterior horns. These cells are not scattered irregularly through the gray matter, but are collected into groups. These groups are quite distinct in the anterior horns, in some cases being small, and only found in a single segment; in others being long, and extending through several segments. This varying arrangement of the anterior groups at different levels is seen in the figure (Fig. 3639, 1 to 6). The function of the cells in the anterior horn is to govern the motion and nutrition of the motor mechanisms of the body.

The more exact localization of motor functions in the groups of cells in the cervical and lumbar enlargements has been attempted by Ross and Spitzka. There are some of these groups, viz., the inner antero-lateral and postero-lateral groups (Fig. 3639, 1, 2, and 3), which develop early in fœtal life, and are common to man and the less highly developed vertebrates. These are thought to

govern the fundamental movements common to man and animals, and earliest acquired in children, viz., flexion and extension, abduction and adduction of the limbs. Other groups, viz., anterior and median groups (Fig. 3639, 4 and 5), are found only in monkeys and man, and the central groups (Fig. 3639, 6) in man alone. These are also found to develop later than the others. They are therefore thought to govern the accessory movements, which are more specialized and depend on finer adjustment, such as the act of walking upright, pronation and supination, and the finer motions of the hands and fingers, actions which are learned some months later than those of a fundamental kind. In some cases of disease, limited to these groups of cells, poliomyelitis anterior, the symptoms have been found to justify this distinction, loss of power and atrophy of certain muscles being produced by a lesion in certain groups of cells. The connection of the different groups, in various segments, with individual muscles, as far as at present known, is shown in the table accompanying this article.[1]

The arrangement of cells in the posterior horns is different from that in the anterior horns. There is a column of cells extending through the lower dorsal region, known as the vesicular column of Clarke, and situated in the median and inner part of the horn. The column begins in the third lumbar segment, and extends upward to the seventh dorsal segment. Its probable function is to regulate the vaso-motor and sympathetic nervous mechanisms.[2] There is a continuous column of cells in the middle of the posterior horn, not collected together into groups, but scattered through the neuroglia and gelatinous substance of the posterior horn. These cells are very small in size, and thus contrast markedly with those already described. It is probable that the gelatinous mass in the posterior horn has something to do with the sensory function, for it is present in the nervous system wherever a sensory nerve ends. The sensations of touch, temperature, and pain are carried into the posterior horns by the posterior nerve-roots, which terminate in these cells and the gelatinous substance.

All the cells of the gray matter give off branching processes which anastomose, forming a dense net-work of

Localization of the Functions of the Segments of the Spinal Cord.

Segment.	Muscles.	Reflex.	Sensation.
Second and third cervical..	Sterno-mastoid, trapezius. Scaleni and neck. Diaphragm.	Hypochondrium (?). Sudden inspiration, produced by sudden pressure beneath the lower border of ribs.	Back of head to vertex. Neck.
Fourth cervical............	Diaphragm. Deltoid. Biceps, coraco-brachialis. Supinator longus. Rhomboid. Supra- and infra-spinatus.	Pupil, fourth to seventh cervical. Dilatation of the pupil produced by irritation of neck.	Neck. Upper shoulder. Outer arm.
Fifth cervical	Deltoid. Biceps, coraco-brachialis. Brachialis anticus. Supinator longus. Supinator brevis. Deep muscles of shoulder-blade. Rhomboid, teres minor. Pectoralis (clavicular part). Serratus magnus.	Scapular, Fifth cervical to first dorsal. Irritation of skin over the scapula produces contraction of the scapular muscles. Supinator longus. Tapping its tendon in wrist produces flexion of forearm.	Back of shoulder and arm. Outer side of arm and forearm. Anterior upper two-thirds of arm.
Sixth cervical	Biceps, brachialis anticus. Pectoralis (clavicular part). Serratus magnus. Triceps. Extensors of wrist and fingers. Pronators.	Triceps. Fifth to sixth cervical. Tapping elbow tendon produces extension of forearm. Posterior wrist. Sixth to eighth cervical. Tapping tendons causes extension of hand.	Outer side of arm and forearm. Inside and front of forearm.
Seventh cervical..........	Triceps (long head). Extensors of wrist and fingers. Pronators of wrist. Flexors of wrist. Subscapular. Pectoralis (costal part). Latissimus dorsi. Teres major.	Anterior wrist. Seventh to eighth cervical. Tapping anterior tendon causes flexion of wrist. Palmar, seventh cervical to first dorsal. Stroking palm causes closure of fingers.	Inner and back of arm and forearm. Radial distribution in the hand.
Eighth cervical	Flexors of wrist and fingers. Intrinsic muscles of hand.		Forearm and hand; median and ulnar areas.
First Dorsal...............	Extensors of thumb. Intrinsic hand muscles. Thenar and hypothenar eminences.		Ulnar distribution to hand.
Second and twelfth dorsal..	Muscles of back and abdomen. Erectores spinæ.	Epigastric, fourth to seventh dorsal. Tickling mammary region causes retraction of the epigastrium. Abdominal, seventh to eleventh dorsal. Stroking side of abdomen causes retraction of belly.	Skin of chest and abdomen, in bands running around and downward, corresponding to spinal nerves. Upper gluteal region.
First lumbar	Ilio-psoas. Sartorius.	Cremasteric, first to third lumbar. Stroking inner thigh causes retraction of scrotum.	Skin over groin and front of scrotum.
Second lumbar	Ilio psoas, sartorius. Flexors of knee (Remak). Quadriceps femoris.	Patella tendon. Striking tendon causes extension of leg.	Outer side of thigh.
Third lumbar..............	Quadriceps femoris. Inner rotators of thigh. Abductors of thigh.	Bladder centre. Second to fourth lumbar.	Front of thigh.
Fourth lumbar	Abductors of thigh. Adductors of thigh. Flexors of knee (Ferrier). Tibialis anticus. Peroneus longus.	Rectal centre. Fourth lumbar to second sacral. Gluteal. Fourth to fifth lumbar. Stroking buttock causes dimpling in fold of buttock.	Inner side of thigh and leg to ankle. Inner side of foot.
Fifth lumbar..............	Outward rotators of thigh. Flexors of knee (Ferrier). Flexors of ankle, peronei. Extensors of toes.	Achilles tendon. Over-extension causes rapid flexion of ankle, called ankle clonos.	Lower gluteal region back of thigh. Leg and foot outer part.
First and second sacral....	Flexors of ankle. Long flexor of toes. Intrinsic muscles of foot.	Plantar. Tickling sole of foot causes flexion of toes and retraction of leg.	Leg and foot except inner side. Perineum and back of scrotum. Anus.

nerve-fibrillæ around the groups of cells. This net-work is supported by a trellis of neuroglia, and through it impulses pass in all directions, uniting the functions of the various cell-groups, and of the sensory and motor areas of the cord. It is probable that impulses coming to the segment, either from the periphery or from the brain, are not conveyed directly to the cells of the segment, but are distributed through the medium of this net-work of fibres to several groups of cells.

Furthermore, each segment controls in some degree the processes of nutrition in the part of the body with which its sensory nerves are connected. It regulates the vaso-motor tone in the organs and limbs, and it influences processes of growth and repair in the skin and mucous membranes. But the existence of trophic cells in the cord has not been proven. Nor can the automatic mechanisms of the cord be assigned to definite cells. They can only be referred to the gray matter of certain segments.

The function of the gray matter of the individual segments is shown in the preceding table. The facts upon which this table has been prepared are gathered from comparative anatomy, from physiological experiment, and from pathological observation. The level of the segment is given; the muscles governed by the groups of cells in it are mentioned so far as they are at present known; the reflex and automatic mechanisms governed by each segment are recorded, and the manner of producing the reflex acts; and the area of skin which sends its sensory nerves to the individual segments is described.

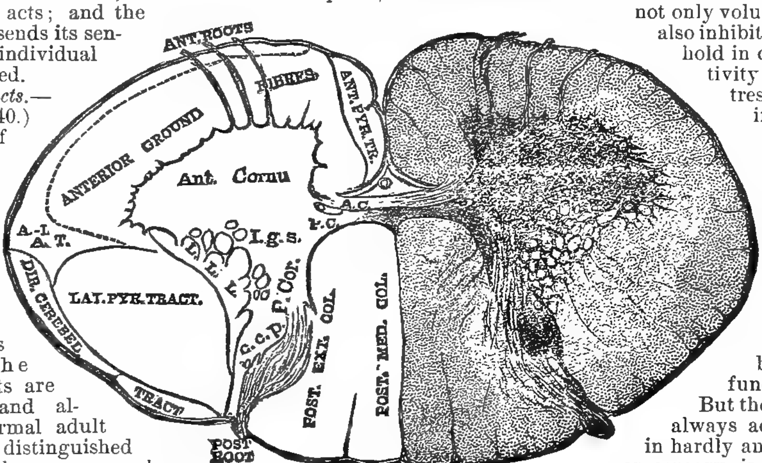


FIG. 3640.—(From Gowers.) Diagram of a Section of the Spinal Cord in the Cervical Region. A.C., Anterior commissure; P.C., posterior commissure; I.g.s., intermediate gray substance; P.Cor., posterior cornu; c.c.p., caput cornu, post.; L.L.L., lateral limiting layer; A.=L.A.T., antero-lateral ascending tract.

B. The White Tracts.—(Figs. 3639 and 3640.) The gray matter of the spinal segment is surrounded by white nerve-tracts, whose function is the transmission of impulses between adjacent and distant segments, and between the various segments and the brain. These tracts are quite numerous, and although in the normal adult cord they cannot be distinguished from one another, there are several means by which their limits are determined. Thus in fœtal cords of various ages different tracts can be distinguished, by the fact that they develop at different times. And in diseased cords pathological processes are often strictly confined to certain tracts. This is especially true of the processes known as secondary degenerations, by means of which the exact boundaries, the length, and the function of the various tracts have been ascertained. The older division of the columns of the cord into anterior, lateral, and posterior, must be set aside in favor of the later divisions founded on these facts.

In a cross-section of the cord at the cervical region the following tracts are seen in each half of the segment:

1. *The motor tracts*, two in number, which come through the anterior pyramids of the medulla, from the motor region of the cerebral cortex on either side of the fissure of Rolando. It will be remembered that the pyramids of the medulla decussate partially just at the upper limit of the spinal cord.[3] The majority of the fibres of each pyramid cross the median line to the lateral column of the spinal cord. The remainder pass directly onward into the anterior column. Those that cross over are called the crossed pyramidal tract. Those that do not cross are called the direct or anterior pyramidal tract, or column of Türck. The latter lies along the side of the anterior fissure of the cord, and is called the anterior median column (Fig. 3639, I). The former lies in a triangular space in the posterior part of lateral column, bounded by other tracts on all sides (Fig. 3639, IV). These motor tracts differ somewhat in size in different cords. When only a few fibres from the medulla cross over, the anterior median column is large and the opposite lateral pyramidal tract is small; but this is the exception. As a rule the lateral tract is three times the size of the anterior one. They differ also in length; for the anterior median column only extends to the mid-dorsal region, but the crossed pyramidal tract extends to the very lowest segment of the cord. They both send in their fibres to the anterior gray horns of the cord at all levels, and therefore decrease in size as they pass downward. They both transmit voluntary impulses from the brain to the anterior motor cells of the cord, a single nerve-fibre in the motor tract carrying an impulse which reaches several groups of cells through the fine net-work of fibres within the gray horn, in which it terminates. They both degenerate downward after any lesion which cuts them off from their nutrient cells in the cerebral cortex. If that lesion is in the brain on one side, the anterior median column on that side, and the crossed pyramidal tract on the opposite side, will be degenerated in the cord. If the lesion is in the cord on one side, both motor tracts on that side will degenerate downward. If the lesion divides the entire cord, the degeneration will be bilateral in both columns. These motor tracts transmit not only voluntary impulses, but also inhibitory impulses, which hold in check the reflex activity of the spinal centres. Hence a lesion in their course produces not only paralysis, but also a loss of control over the bladder and rectum, and an increase in the spinal reflex activity.

2. *The Association Tracts.* Each spinal segment has been shown to have functions of its own. But the different segments always act in harmony, and in hardly any act, either motor or sensory, is any segment independent of the rest. Hence a large part of the white matter of the cord is composed of tracts, shorter or longer, joining the various segments with one another, and associating their actions. These association tracts lie about the anterior horns of the cord, on their different sides, making up together a large antero-lateral column which has been divided artificially into an anterior column (Fig. 3639, II), and a general lateral column (Fig. 3639, III), the latter having a portion between the crossed pyramidal tract and the outer surface of the gray matter which has been called the lateral limiting layer (Fig. 3639, V). All these tracts are about the same size at all levels of the cord, thus differing from the motor tracts, which decrease in size from above downward, and from the sensory tracts, which increase in size from below upward. They degenerate but a short distance in any transverse lesion of the cord. It should not be forgotten that the anterior nerve-roots pass out of the cord through the anterior column, and that many of these roots pass upward or downward for some distance before making their exit. Hence this column is not wholly made up of association tracts. There is no form of disease limited to the association tracts exclusively, hence it is impossible to bring any known symptoms into connection with the lesion when they are affected in a general myelitis.

3. *The Sensory Tracts.* These occupy the posterior

columns of the cord, of which there are two on each side of the posterior median septum, viz., the postero-external column, or column of Burdach (Fig. 3639, VI), and the postero-median column, or column of Goll (Fig. 3639,

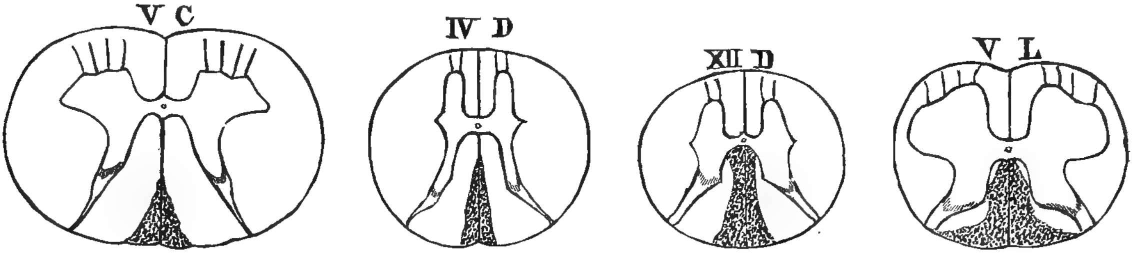
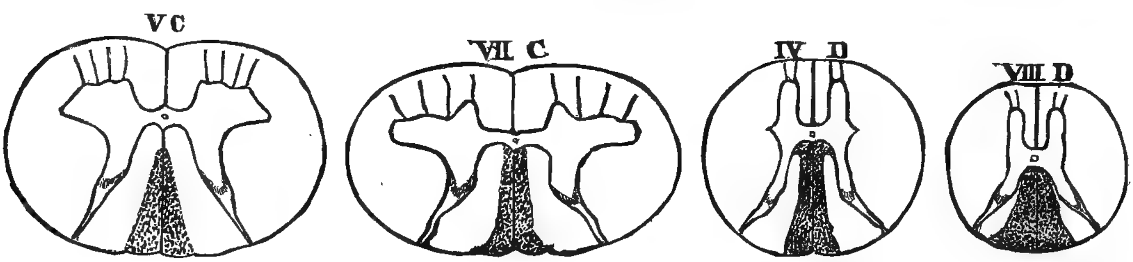


FIG. 3641.—Area of Ascending Degeneration after Compression of Cauda Equina, involving the Sciatic Nerve-roots only.

VII). The column of Burdach is made up very largely of the posterior nerve-roots which enter it and pass upward or downward for some distance before leaving it, to end in the posterior gray horn, or to enter the column of Goll. The column of Goll is made up wholly of long fibres extending from the posterior nerve-roots to the



medulla. The exact areas taken up respectively by the short posterior roots and the long fibres differ greatly at different levels, and they have only recently been determined by a study of the tracts degenerated after transverse lesions at different levels. These recent investigations deserve a moment's notice.

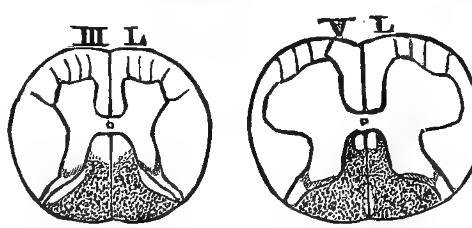


FIG. 3642.—Area of Ascending Degeneration after Compression of Cauda Equina, involving all the Sacral and Lumbar Nerves.

If the posterior nerve-roots are divided between the posterior spinal ganglia and their entrance into the cord, an ascending degeneration occurs in the cord. It is by observing the course of this ascending degeneration that the upward continuation of the sensory nerves has been determined.[4] The area of the posterior columns of the cord which degenerates upward differs in different cases. When the sciatic nerve-roots

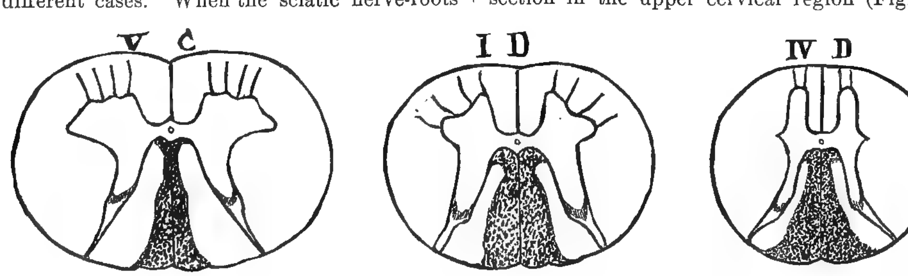


FIG. 3643.—Area of Ascending Degeneration after a Transverse Lesion of the Mid-dorsal Region.

alone are divided, or the sacral portion of the spinal cord is destroyed, the ascending degeneration occupies a large area of the posterior columns in the lumbar region, a smaller area in the dorsal region lying wholly in the column of Goll, and the posterior median portion only of the column of Goll in the upper dorsal and cervical regions (see Fig. 3641). When all the nerve-roots of the cauda equina, including both sacral and lumbar nerves, are compressed and destroyed, the ascending degeneration occupies a somewhat larger area than in the first case, involving both posterior columns as high as the middle of the dorsal region and a large part of the column of Goll in the cervical region (see Fig. 3642). When a transverse lesion of the cord in the dorsal region cuts off all sensory conduction from below the level of the mid-dorsal region, the area of ascending degeneration is still larger than in the first two cases, and in the cervical region involves the entire column of Goll (see Fig. 3643). When the cord is divided in the lower part of the cervical enlargement, the ascending degeneration involves a very large area, including both the entire column of Goll and a part of the column of Burdach in the upper cervical region (see Fig. 3644).

From these facts it becomes evident that the posterior nerve-roots contain a number of fibres which, after entering the cord, turn upward and pass on to the medulla oblongata, each successive set from below upward lying a little in front of, and outside of, the preceding set, and gradually filling out the entire column of Goll and a portion of the column of Burdach. In a cross-section in the upper cervical region (Fig. 3640) it can, therefore, be affirmed that the fibres in the posterior median part of the column of Goll transmit sensory impulses from the legs; that the fibres in the median and lateral portion of the column of Goll transmit sensations from the thighs and pelvis; that the fibres in the anterior portion of the column of Goll transmit sensations from the body exclusive of the arms; and that the median part of

the column of Burdach transmits sensations from the arms. Experimentation on animals has proven that the nerve-fibres entering the cord in the posterior nerve-roots, and passing upward in this manner to the medulla, degenerate upward upon the side on which they enter. There is no reason, therefore, to believe that in man there is any decussation in the spinal cord of the fibres thus far described. But since all sensations, except those of muscular sense, are known to cross over to, and ascend in, the opposite side of the cord in man, immediately after their entrance, it follows that the fibres thus far considered have for their function to transmit the sensations of muscular sense. And this conclusion is further established from the facts gathered from the pathology of locomotor ataxia. For in this disease, in which the muscular sense is the one most seriously impaired, the same areas of degeneration are found. There is, first, the primary sclerosis in the column of Burdach, involving the nerve-roots in it, and secondly, the secondary degeneration in the column of Goll, whose extent is determined by the extent of the primary lesion. The higher the primary lesion advances, the greater the area of the column of Goll involved. Since cases have been observed in which the sensations of touch, of pain, and temperature, and of the muscular sense, have been affected singly, it follows that the tracts conveying these sensations must be separate from one another. The fibres so far described terminate in the nuclei of Goll and Burdach. But from these nuclei the fibres of the interolivary tract and lemniscus arise, which are known to decussate in the sensory decussation of the medulla, and are known to transmit sensations of muscular sense exclusively. Hence the conclusion seems warranted that the sensory tract for muscular sense lies in the column of Goll for all parts below the arms, and in the median part of the column of Burdach for the arms.

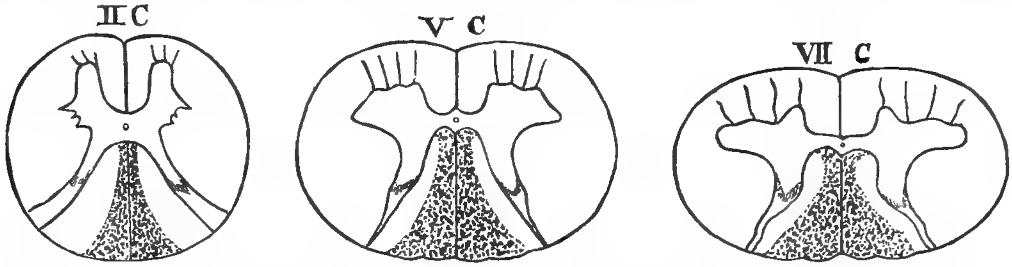


Fig. 3644.—Area of Ascending Degeneration when the Lower Cervical Region of the Cord is involved by a Transverse Lesion.

With regard to the sensory tracts for touch, pain, and temperature, our knowledge is much more indefinite. These sensations enter the cord by the posterior nerve-roots. But these roots do not send all of their fibres upward in the path already described. And if the area of the cord occupied by the column of Goll in the cervical region be compared with the entire area of the posterior nerve-roots, it will be seen that a mere fraction of the fibres entering the cord by these roots ascends to the medulla. The large remainder terminate in the cord. Anatomists describe various manners of termination. Some fibres end directly in the posterior gray horn; others pass through it to reach the anterior gray horn; others still, cross over through the posterior gray decussation to the other side of the cord. Many fibres enter the column of Burdach and pass directly through it to enter the gray matter in the vicinity of the vesicular column of Clarke; others ascend some distance in the column of Burdach before they enter the gray matter, and a few turn downward in the column of Burdach before ending in the gray matter. From the fact that general myelitis involving the posterior gray matter is always attended by sensory symptoms, it is concluded that many sensations are sent to the cells of the posterior horns. From the posterior gray matter nerve-fibres pass backward into the columns of Goll and Burdach, and mingle with the fibres of those columns, presumably ascending with them to the medulla. It is not improbable that these fibres transmit sensations of touch. Even in the most extreme cases of secondary ascending degeneration in the posterior columns, after division of the nerve-roots, many fibres in those columns escape. It is therefore possible that some of the fibres making them up have their origin and nutrient cells in the gray matter of the posterior horns, rather than in the posterior spinal ganglia. Hence the facts do not exclude the possibility of the transmission upward of sensations of touch in the posterior columns of the cord after such sensations have crossed the median line in the gray matter. And that they are transmitted in this region the older physiological experiments established. Other physiological experiments point to a transmission of sensations of touch in the lateral columns of the cord. And Gowers has established the existence of a tract in the periphery of the antero-lateral column (Fig. 3639, VIII), lying anterior to the direct cerebellar tract, which degenerates upward after transverse lesions. This is called the antero-lateral ascending tract. Positive facts, however, do not yet warrant the statement that a sensory tract is to be found in man in the lateral columns. And the fact that in lateral sclerosis, and in amyotrophic lateral sclerosis, as well as in ataxic paraplegia and in Friedrich's form of locomotor ataxia, in all of which the lateral columns are extensively involved and the fibres passing to the antero-lateral column from the gray matter must be implicated, but in none of which sensory symptoms are present or severe, would seem to prove that in man sensations of touch are not transmitted in the lateral columns. It is evident, therefore, that sensations of touch are probably transmitted upward through the posterior columns of the cord, after crossing over at the level at which they enter, but that a definite limitation of the tract through which they pass is impossible.

The sensations of temperature and pain are uniformly preserved or lost together, hence it is concluded that they pass in the same tract. No definite position can be assigned as yet to that tract. In syringo-myelitis, in which the lesion is limited to the central gray matter of the spinal cord between the anterior and posterior horns, a loss of temperature and pain sensations in all parts below the level of the lesion has been observed, and it has been concluded that these sensations are transmitted by the gray matter. Gowers believes that they pass in his antero-lateral tract, but the conclusion rests upon too small a number of observations to be hastily adopted. Spitzka, from a single case, concludes that sensations of pain pass in a triangular area on the periphery of the posterior columns, at the junction of the columns of Goll and Burdach. But each of these views is open to objections, and facts are wanting to determine between them.

4. *The Direct Cerebellar Column.* The last column of the cord to be described is one lying upon the outer surface of the lateral column, and extending from the lower dorsal region to the corpus restiforme of the medulla, and thence to the cerebellum. Its termination in that organ has led to its name—the direct cerebellar tract. It is made up of fibres whose origin is in that column of cells lying in the median part of the posterior horn known as the vesicular column of Clarke. The cells are only found in the dorsal region, hence all the fibres in this tract come from the dorsal segments of the cord. They reach

the lateral periphery of the cord by passing diagonally through the lateral column. They are supposed to transmit sensations upward from the Clarke column of cells to the cerebellum, because they degenerate upward after a transverse lesion of the cord. The function of both the cells and the tract is uncertain. From recent investigations by Gaskell, however, it seems probable that the vesicular column of Clarke is connected with the vaso-motor and sympathetic nervous systems by means of very small nerve-fibres extending from the sympathetic ganglia into the cord. If so, the function of the direct cerebellar tract is to transmit those rather indefinite sensations from the viscera, or to act as a tract for unconscious sensations or motor impulses necessary in a central regulation of visceral and vascular action. The hypothesis that they convey muscular-sense sensations from the trunk is hardly warranted, since these must be of little importance in lower animals, who do not walk erect—in which animals, however, this column is well developed.

II. Symptoms Leading to the Diagnosis of Local Lesions.—Such being the functions of the various parts of the spinal cord, it remains to discuss the symptoms arising when various parts are diseased. And it will be as well to approach this subject from the side of the symptoms rather than of the lesion, since it is the object to determine the lesion in any case.

1. *Spinal Paralysis.*—The motor tract conveying voluntary impulses from the brain to the muscles consists of two elements: first, the cerebro-spinal element, and secondly, the spino-muscular element. Each element consists of a set of nerve-cells and their outgoing fibres, which not only transmit impulses from the cells but are nourished by them. The cells of the cerebro-spinal element lie in the cerebral cortex. Their fibres make up the motor tract through the brain and through the direct and crossed pyramidal tracts of the spinal cord.[5] These fibres terminate in the net-work of the anterior horns of the cord at various levels, some of them reaching its very lowest part. Any lesion in the cells of the cortex, or in the course of the fibres which cuts them off from those cells, results in the degeneration downward of the cerebro-spinal element to its termination in the motor cells of the spinal cord. The *first form of spinal paralysis* is due to a lesion at the spinal part of this cerebro-spinal element of the motor tract. If the cord is divided by a transverse lesion at any point, the function of this element of the motor tract is thereby suspended. As a result, voluntary motion is arrested in the parts below the lesion. If the lesion involves but one-half of the cord, it is the limbs on the side of the lesion which are paralyzed. If it involves the entire cord, both sides are paralyzed. The extent of the paralysis depends upon the level of the lesion; the higher the lesion the more extensive the paralysis. The degree of the paralysis will depend on the character of the lesion, slight compression of the cord at one point by a tumor, or a pachymeningitis, or a projecting vertebra being followed by some stiffness of movement and rigidity of the muscles, with weakness, rather than by absolute loss of power in the parts below the level of the pressure. The cerebro-spinal element of the motor tract also transmits the inhibitory impulses which continually keep the spinal reflex and automatic mechanisms in check. A lesion of this tract, therefore, produces not only weakness and paralysis, but also increase of the deep reflexes, and impairment of control over the bladder and rectum. The muscular action of the limbs being no longer controlled by the brain, is governed wholly by the centres in the spinal cord. These act in response to sensory impulses, or spontaneously, without check, and hence the preponderating strength of flexor over extensor muscles tends to produce a position of adduction and flexion of the limbs which are paralyzed, and a heightened muscular tone, with tendency to rigidity. The nutrition of the paralyzed muscles may suffer somewhat from disuse, and from the attendant vaso-motor paresis, but no rapid atrophy is noted when the cerebro-spinal element of the motor tract is alone involved. And it is also to be noted that the paralysis affects the entire limb or limbs, and not any special group of muscles. In these cases the electric contractility remains normal in the paralyzed limbs.

A typical example of this form of spinal paralysis is seen in compression of the spinal cord, below the lesion, and in lateral sclerosis or spastic paraplegia (*q.v.*).

The *second form of spinal paralysis* is due to a lesion in the spinal part of the second element of the motor tract, viz., the spino-muscular element. This consists of the cells of the anterior gray horns of the cord, and the anterior nerve-roots which pass out through the anterior columns of the cord. Destruction of the cells suspends both voluntary and reflex motor impulses to the muscles. The cells not only control the motion, but also the nutrition, of the nerves to which they give origin, and of the muscles to which these nerves go. Therefore destruction of the cells produces atrophy of the muscles with which they are connected. If the destruction is gradual, the atrophy is gradual, as in progressive muscular atrophy. If the destruction is rapid, the atrophy is rapid, as in infantile paralysis. The degree of the atrophy depends upon the degree of destruction of the group of cells which govern the particular muscle affected. If the group is wholly destroyed, the muscle becomes totally atrophied. In addition to paralysis with atrophy there is in the second form of spinal paralysis a change in the electric reaction of the paralyzed muscles. They lose their contractility to the faradic current, and alter their contractility to the galvanic current, responding in a sluggish manner, and to the positive more readily than to the negative pole. This is called the Reaction of Degeneration (*q.v.*).

The extent of the paralysis depends upon the extent of gray matter affected, and a reference to the table of the localization of functions already given will enable one to determine the effect of a lesion at any particular segment, or through a group of segments, of the spinal cord. A typical example of the second form of spinal paralysis is found in infantile paralysis or poliomyelitis anterior. The muscles in this disease are paralyzed, atrophied, exhibit the reaction of degeneration, and lose their reflex excitability. An entire limb is rarely affected, certain groups of muscles being usually paralyzed together, *e.g.*, the deltoid, biceps, brachialis anticus, and supinator longus (upper arm group); or the extensors of the wrist and hand muscles (lower arm group); or the glutei and thigh muscles, with the tibialis anticus (thigh group); or the posterior tibial and peroneal groups of the leg (leg group). The muscles affected are not those which are supplied by a single peripheral nerve—a fact which enables a diagnosis between a lesion in the spinal cord and a lesion in a peripheral nerve to be easily made—but those which act together to produce a definite physiological act.

The contrast between these two forms of spinal paralysis can be seen at a glance in the following table:

First Type of Spinal Paralysis.	Second Type of Spinal Paralysis.
Lesion in pyramidal tracts.	Lesion in anterior gray horns.
Paralysis usually on both sides equally, in legs, or in legs and arms, never in arms alone.	*Paralysis* may be limited to any single limb, and rarely affects both limbs equally.
All muscles are about equally affected. No muscles are entirely normal.	Certain groups of muscles only are affected. Others escape wholly.
Muscular tone is heightened.	Muscular tone is diminished.
Tendency to rigidity appears.	Muscles are relaxed.
Reflex excitability is increased.	Reflex excitability is lost.
Atrophy is absent, or is slight; and merely due to disuse, hence is gradual in progress. It affects the entire limb.	*Atrophy* is always present in the paralyzed muscles. It advances rapidly, and may become extreme.
Electric contractility is unchanged.	*Electric contractility* is changed. Reaction of degeneration is present within two weeks of the onset.
Vascular tone is diminished; cyanosis and œdema may occur.	*Vascular tone* is diminished, but œdema does not occur.
Paralyzed limb is cold, and sweat may be increased.	Paralyzed limb is cool, but sweat is not increased.
Trophic disturbances in the skin are not infrequent.	*Trophic disturbances* in the skin do not occur.
The control over the bladder and rectum may be diminished or lost.	The control over the bladder and rectum is not impaired.
Example: Spastic paraplegia.	Example: Infantile paralysis.

The *third type of spinal paralysis* is a combination of the first and second types. When a transverse lesion of the spinal cord entirely destroys a single segment, it produces paralysis of the first type in the parts below the level of the lesion by cutting off the tracts to those parts, and paralysis of the second type at the level of the lesion by destroying the gray motor cells at that level. The general effect of such a lesion depends entirely upon the level at which it occurs; the higher the lesion, the greater the extent of the first type of paralysis. The distribution of the second type will depend on the level of the segment involved. The greater the extent of the lesion at the level affected, the greater the extent of the second type of paralysis. An example of this is also found in amyotrophic lateral sclerosis. When a longitudinal lesion of great extent occurs—such as the general destruction of the cord in general myelitis—the second type of paralysis is the form which is found, but all the muscles are affected, not merely a few groups. The bladder and rectum are also affected, and bed-sores are frequent.

In any case of spinal paralysis, if the electric condition of the muscles paralyzed be ascertained by the aid of a faradic battery, and the diagnostic points here brought together be applied, reference to the table of the localization of functions will enable the exact level of the lesion to be determined.

SPINAL ANÆSTHESIA.—The course of the sensory tract in the spinal cord is still somewhat imperfectly understood. It is known that all sensory impulses reach the spinal cord through the posterior nerve-roots, which partly enter the apex of the posterior horn, and partly enter the column of Burdach, and pass upward as already described. The sensations of muscular sense ascend on the same side as that on which they enter. Those of touch, temperature, and pain cross over as soon as they enter to the opposite side and ascend in it. The various views regarding the tracts transmitting these sensations have been already stated.

In transverse lesions of the spinal cord the area of anæsthesia present in the skin depends upon the level of the lesion. Anæsthesia of the feet, legs, and thighs, excepting their inner surfaces, indicates a lesion in the sacral and lower lumbar enlargement. Anæsthesia of the entire surface of the legs, thighs, and buttocks, including the genitals, indicates a lesion involving the entire lumbar enlargement. Anæsthesia around the body, attended by the so-called "girdle sensation," as if a band were drawn around the trunk, indicates a lesion in the dorsal region of the cord, and its level is indicated by observing the exact nerve above which sensation is normal. Anæsthesia of the trunk, and of the inner surface of the arms and one-half the hands, indicates a lesion of the lower portion of the cervical enlargement, not higher than the seventh cervical segment. Anæsthesia of the trunk and entire hand, forearm, and arm—the neck, upper chest, and outer surface of the shoulder only escaping—indicates a lesion as high as the fifth cervical segment. Transverse lesions higher than this cause sudden death from paralysis of the phrenic nerves. Limited areas of anæsthesia in the skin, at any part of the body, are to be ascribed rather to lesions in the peripheral nerves or nerve-roots (as in tumors of the cord) than to any local lesions in the cord itself; for posterior poliomyelitis as a distinct lesion is unknown. The areas of the skin which are connected with the various segments have been described already in the table. When a transverse lesion involves but one-half of the spinal cord, the anæsthesia is found upon the side opposite to the lesion, below the level of the lesion, and extends around the trunk in a band at the level of the lesion, the width of the anæsthetic band depending upon the longitudinal extent of the lesion. On the side of the lesion below the level of the anæsthetic band the skin is hypersensitive to touch. Such unilateral lesions produce a loss of muscular sense on the hyperæsthetic and paralyzed side, not upon the side of the anæsthesia—a fact which proves that the sensations of muscular sense do not decussate within the cord.

Hyperæsthesia sometimes occurs from spinal lesions, but is quite rare. It indicates an irritation of the sensory tracts in the cord by hyperæmia, or by pressure, rather than destruction of those tracts. Gowers suggests that this hyperæsthesia may be due to an increased irritability of the part of the cerebral cortex to which the injured tracts pass, as well as to an intensification of the impression passing in them. *Pain* is a rare symptom in spinal-cord disease, excepting in locomotor ataxia. And here it is to be ascribed to irritation of the posterior nerve-roots within the cord, similar in character to their irritation without the cord, as occurs in meningitis and in diseases of the vertebral column. *Numbness* is a frequently mentioned symptom of spinal-cord disease, and has some value in local diagnosis, as the area of the skin in which the numbness is felt depends upon the level of the cord affected. Hence, when the numbness is limited to certain parts, especially to the extremities, a reference to the table will indicate the segment of the cord which is diseased. Thus in locomotor ataxia the beginning of numbness or pain in the little fingers indicates that the disease has advanced up the spinal cord and has reached the first dorsal and lowest cervical segments.

SPINAL ATAXIA.—This symptom always indicates an affection of the posterior nerve-roots in their passage through the column of Burdach. Inco-ordination is due to an interference with the reception of sensations of muscular sense which are sent in from the skin, joints, and muscles. These sensations may be intercepted as they pass through the nerves, for ataxia is a symptom of toxic multiple neuritis; they may be intercepted as they pass through the column of Burdach, as is the case in locomotor ataxia; they may be intercepted in the brain by lesions in the lemniscus (see Pons) or in the cerebellum (see Cerebellum). It is probable that a portion of the muscular sensations are sent to the gray matter of the cord, producing reflex action of balancing, and unconscious co-ordination, and that the remainder are sent upward to the brain. For the inco-ordination in cerebral disease, when the latter only are disturbed, is less severe and intense than in spinal-cord disease, where all are implicated. Ataxia from neuritis is usually accompanied by tenderness in the nerves and muscles. Ataxia from cerebellar disease is only present in the act of walking, and is attended by vertigo. Ataxia from spinal disease is not attended by these two symptoms, but is usually accompanied by severe lightning pains and by loss of deep reflexes, together with other characteristic symptoms of locomotor ataxia (*q.v.*).

It must be stated here that in lesions of the spinal cord, as in those of the nerves, the motor symptoms are usually more pronounced than the sensory symptoms; and even when the spinal cord is greatly compressed, or disintegrated, sensory impulses may continue to pass after motor impulses are entirely arrested.

DISTURBANCES OF THE SPINAL REFLEX AND AUTOMATIC ACTION.—Whatever view may be held regarding the nature of spinal reflex action, it is well established that certain structures are necessary to its production. It is necessary that a sensory nerve from the surface of the body be capable of transmitting impulses to the spinal cord. It is known that the fibres transmitting the centripetal impulses from the skin enter the apex of the posterior horn, while those transmitting impulses from the tendons enter the median surface of the posterior gray matter after traversing the lateral part of the column of Burdach called the root zone. It is also necessary that the net-work of nerve-fibres through which impulses pass from the posterior gray matter to the cells of the anterior horn be intact. It is also necessary that the groups of cells in the anterior horn, and the motor nerves from them to the muscles, be in a normal state, or capable of exercising their functions. These structures, together, make up a reflex arc, and a lesion in any part of this arc will arrest the reflex activity. Thus neuritis, outside the cord or due to meningitis, may interfere with the conduction of impulses to and from the cord; posterior sclerosis may arrest centripetal impulses as they reach the root zone; general myelitis may destroy the net-work of fibres within the gray matter; and anterior poliomyelitis may

destroy the motor cells in the anterior horn. All these diseases, therefore, may cause a loss of tendon reflex. There are reflex activities governed by almost every segment of the cord, as may be seen in the table ; and the particular reflex which is suspended in disease will depend wholly on the location of the lesion. Hence the loss of any one or more reflexes gives important information as to the seat of the lesion. And this can be ascertained after examination of the patient by a reference to the table. It has been already stated that an inhibitory influence is exerted by the brain upon spinal activity, and that this influence is conducted to the spinal motor cells through the motor tracts in the lateral column. Anything which impairs the conduction of impulses through this tract will result in removing restraint from the spinal reflexes and allowing them full sway. Hence an increase in deep spinal reflexes indicates a suspension of function in the lateral pyramidal tracts. A transverse myelitis, therefore, will cause an increase of the reflexes below the level of the lesion, and a loss of the spinal reflex governed at the level of the lesion. This has been already mentioned in connection with spinal paralysis. The skin reflexes are, however, not increased by lesions in the pyramidal tract.

The automatic activity of the cord includes the mechanisms of micturition and defecation. These mechanisms are complex reflexes, several sensory impulses combining to produce a compound motor effect, a part of which is inhibitory and a part of which is active. Thus in micturition, the sensations of pressure on the sensitive neck of the bladder, and of distention of the entire organ, produce an inhibition of the motor impulses which normally hold the sphincter tight, and set in activity the motor impulses which contract the detrusor urinæ, thus emptying the bladder. The same is true, *mutatis mutandis,* of the other automatic acts. The structures necessary for any one of these acts are similar to those underlying the simple spinal reflex, and the same lesions arresting it may arrest these acts. But the result of such arrest is more serious, for, in the case of the bladder or rectum, retention or passive incontinence of urine or fæces may follow. And if the inhibitory impulses from the brain to these centres are cut off, the voluntary control over these mechanisms is impaired, and the acts cannot be initiated voluntarily, and active incontinence may result. The location of the rectal mechanism is in the lower sacral region. That of the bladder and sexual mechanisms is in the mid-lumbar region. Hence, when these parts are the seat of a lesion, or are cut off from the brain by a lesion at a higher level in the motor tract, incontinence, either active or passive, or retention, may result.

A part of the automatic mechanism of respiration is governed by the cervical and dorsal regions of the cord, and is interfered with in disease in those regions. Lesions of the upper cervical region paralyze the diaphragm and thus cause death.

Disturbance of vaso-motor and trophic functions of the cord may occur from various forms of lesion. Anterior poliomyelitis produces atrophy of the muscles paralyzed, and a sufficient affection of the vaso-motor system to cause objective, as well as subjective, coldness in the limb ; and when the lesion lies deep in the anterior horn, an arrest of development of the bones of the limb affected. General myelitis is usually associated with a tendency to bed-sores upon the parts exposed to pressure, which cannot be avoided by the most scrupulous cleanliness, and to cystitis, and these are ascribed to a disturbance of trophic impulses to the skin and bladder. Posterior sclerosis is sometimes associated with trophic changes, such as perforating ulcers, joint affections (Charcot's arthropathies), and eruptions on the skin. In a few cases of leprosy serious lesions of the posterior gray horns have been observed. In general myelitis there is a partial vaso-motor paralysis, indicated by cyanosis, sluggish circulation, œdema, and coldness, with abnormal sweating in the paralyzed parts. But any definite statement regarding the exact localization of vaso-motor or trophic functions in the spinal cord cannot be made as yet. And recently many vaso-motor and trophic symptoms, formerly supposed to be due to spinal lesions, have been found to be produced by disease in the peripheral nerves. It is, however, established that trophic lesions are most frequently observed when the gray matter of the spinal cord in the vicinity of the central canal, including the vesicular column of Clarke, is the part diseased ; or when all sensation is cut off from the paralyzed limbs by a transverse lesion.

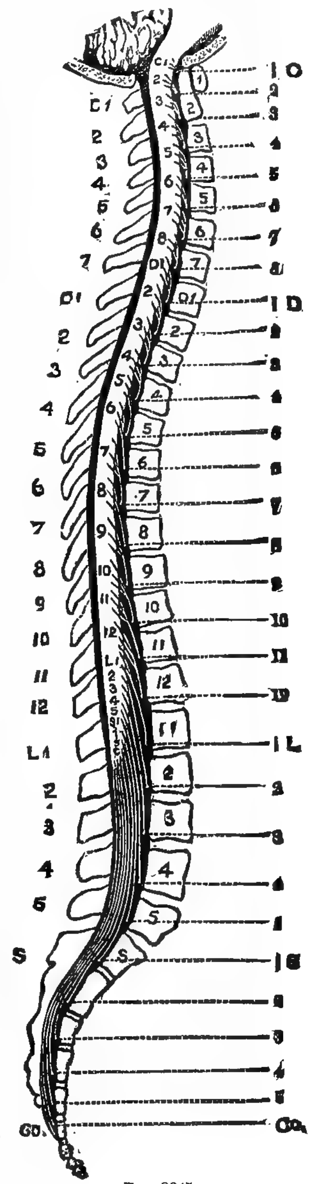


Fig. 3645.

The regulation of urinary excretion is presided over by a centre in the medulla, and the nerve-tract thence to the liver and kidneys is traced through the cervical region of the spinal cord to the first dorsal segment, where it enters the sympathetic chain of ganglia. A lesion in the lateral column of the cervical cord, by involving this tract, may cause a vaso-motor paralysis of either the liver or the kidneys. In the former case diabetes mellitus is produced ; in the latter, diabetes insipidus results. It is therefore necessary, in lesions of the spinal cord, to examine the amount and constituents of the urine.

In any case of spinal disease where it is desirable to localize accurately the lesion, it is suggested that a written summary of the symptoms be compared with the table of localization of the functions of the cord, when it will become evident, by contrasting the normal with the abnormal conditions, what part of the cord is affected. As Bramwell justly observes, "the essence of the clinical examination of the spinal cord consists in the systematic and separate examination of each spinal segment, by observing the motor, sensory, reflex, vaso-motor, and trophic conditions of its body area." Such an examination will lead to accurate diagnosis of local lesions.

But one point remains to be mentioned, that is, the relation of the various segments of the cord to the bodies and spines of the various vertebræ. As the cord extends only to the level of the second lumbar vertebra, its various segments do not lie opposite to the vertebræ from which they are named. The accompanying diagram of Gowers displays the mutual relation between the segments and their nerves, and the bodies of the vertebræ, and no further description is needed.

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M. Allen Starr.

[1] For a full account of the grouping of these cells, see Localization of the Functions of the Spinal Cord, by M. A. Starr, American Journal of Neurology and Psychiatry, vol. iii., p. 443 et seq. Ross: Diseases of the Nervous System, vol. i., p. 629.
[2] Gaskell: Journal of Physiology, 1886.
[3] See Brain and Pons, Diagnosis of Local Lesions in the. The Motor Tract, vols. i. and v.
[4] Schultze, F.: Ueber Secondäre Degeneration im Rückenmarke, Arch. f. Psych., xiv., from which article the figures are taken.
[5] For the anatomy of this motor tract, see Diagnosis of Local Lesions in the Brain, vol. i.

SPINAL CORD DISEASES. General Symptomatology and Diagnosis.—The spinal cord is a conductor of outgoing impulses, which are: 1, motor, to muscles; 2, secretory, to glands; 3, vaso-motor, to blood-vessels; 4, trophic, to skin, muscles, bones.

It conducts ingoing impulses, causing: 1, general sensations—cutaneous, articular, muscular, and visceral; 2, special sensations—tactile, thermic, and muscular; 3, exciting reflex actions, simple and complex, and arousing automatic centres.

The cord contains arrangements of cells forming reflex and automatic centres.

These are the vesical centre, the anal, sexual, uterine, subordinate sweat and vaso-motor centres, cilio-spinal centres, and centres which regulate in a measure the functions of the abdominal viscera and the development of heat.

The symptoms produced by disease of the spinal cord are due to interference with these various functions, and a thorough knowledge of the anatomy and physiology of this organ is the best means of guiding one to their interpretation. Those which may be called the dominant, and, in a measure, characteristic symptoms of spinal cord disease are the following, it being remembered that we have not only the individual symptoms to study, but their distribution and clinical history, in order to learn that they are peculiar to an organ or a disease.

I. Of the motor class we have, in diseases of the spinal cord peculiar paralyses and spasms. These are either bilateral and paraplegic, as is usually the case in adults, or monoplegic and unequally distributed, as is often the case in children. Spinal paralyses are very rarely indeed hemiplegic, and they, of course, never involve the face. They are accompanied with wasting and sensory disorders, and involvement of the organic spinal centres. By these signs we can thus readily distinguish spinal from cerebral paralyses in almost all cases. Paralysis that occurs from involvement of the nerves is usually more circumscribed, and if widespread, as in multiple neuritis, is painful, with the sphincters, vesical and rectal, only very exceptionally involved. Spasm is rare in the paralysis from neuritis, but frequent in that from spinal and cerebral disease.

In general, a paralysis with atrophy and without pain, or one with spasm and pains, means an involvement of the cord; a paralysis with pain and wasting means involvement of the nerves; a paralysis with spasm, but without wasting or much sensory disturbance, means involvement of the brain.

Excessive motor action (hyperkinesis) without paralysis is a somewhat rare condition in spinal cord disease. Spinal convulsions, however, occur in tetanus and as the result of some poisons; while in the spasmodic disorders known as writers' cramp and chorea, the cord is in part involved.

The peculiar electrical reactions in different forms of paralysis are of great help in determining the seat of the disease (see special articles).

II. The pains due to spinal cord disease are somewhat characteristic. They are usually darting in character, and radiate through a number of branches of outgoing nerves; or they are cinctural, causing a feeling as if the trunk were squeezed in a vise. Band-like feelings also occur about the head and lower limbs. Pain and tenderness along the spine occur in spinal irritation, in meningitis, and acute myelitis, but are rare in chronic diseases of the cord. The tissue of the spinal cord is probably somewhat sensitive to painful irritations in the posterior and antero-lateral parts, but practically most spinal pains come from irritation of the posterior roots, or root zones. Anæsthesia rarely follows organic cerebral disease, and it is then unilateral; therefore, when present in any other form of distribution, it is usually a symptom of involvement of the medulla, cord, or nerves. If the lesion is in the cord, the anæsthetic region is most likely to be diffuse and bilateral, and to be limited at a certain level of the limb or trunk. Delayed sensation and allocheiria, or transferred sensation, are usually evidence of cord disease. Parasthesiæ, and in particular burning sensations, are, as a rule, due to neuritis, while a peculiar sense of heaviness, often complained of, is of spinal origin. Ataxia due to disturbance of muscular and articular sensibility used to be thought a sign of disease of the spinal cord, and such is usually the case. But ataxia may occur in neuritis.

It will be seen that the extent and location of sensory symptoms determine the question of spinal or peripheral origin more than the character.

III. In certain spinal affections involving the central gray, such as syringomyelia and progressive muscular atrophy, there are decided disturbances of the vaso-motor system and of the sweat-glands. The involvement is usually widespread and includes a whole limb, or nearly all of the bodily surface. Œdema, hyperidrosis, vaso-motor spasm, and paralysis, occur in a more localized and limited manner, from disease of nerves.

IV. It is quite impossible in many cases to say positively what neuro-trophic changes are due to spinal, and what to peripheral, neural influence.

However, the rule is that the profounder trophic disturbances, such as decubitus, symmetrical gangrene, osseous and articular lesions (arthropathies), scleroderma, and the severe forms of muscular atrophy, are of spinal origin. The more superficial lesions of the skin, such as herpes, glossy skin, etc., and minor degrees of muscular atrophy, are more likely to be peripheral. Muscular atrophies result from degenerative myositis, from neuritis, and from myelitis. For the special characters of the different forms the reader is referred to the articles on these subjects.

V. Among the common symptoms of cord disease are disturbances of the superficial, the deep, and the organic reflexes. The presence or absence of the superficial skin reflexes gives us very little practical information, as they are not abolished or exaggerated without other symptoms. In some cases a study of them may furnish a guide to the height of the cord lesion.

The deep, or tendon, reflexes are always present in healthy persons (the exceptions are not one per cent.). When exggerated, they indicate a great degree of cerebro-spinal irritability (hysteria, neurasthenia), or some cerebro-spinal lesion. Organic disease of the peripheral nerve may usually be excluded.

A loss of tendon reflexes, on the other hand, may be due either to peripheral nerve or spinal cord disease, but not to cerebral disease unless there is also paralysis. If the loss is not due simply to motor paralysis, the trouble may, in the majority of cases, be referred to the cord.

Disturbance of organic reflexes and centres of visceral control is a common, early, and almost pathognomonic sign of disease of the spinal cord. Some vesical weakness, or sexual weakness, may be for years the only sign of approaching degenerative changes. It is only in certain rare cases that the bladder and rectum become involved through inflammation of the nerves (multiple neuritis). In profound cerebral and mental disturbance, control over the organic centres may also be lost.

In diseases affecting the central gray of the cervico-dorsal segments of the cord, pupillary disturbances, retraction or bulging of the eyeball, and facial flushing, pallor, or sweating may occur.

The spinal cord contains thermogenetic centres in its

central gray, and an increase or lowering of bodily temperature from disease of these parts is sometimes observed. A lowering of temperature is especially noticeable in poliomyelitis anterior.

General Pathology.—The spinal cord is subject to nearly all the diseases which affect other tissues of the body. Owing, however, to its peculiarly guarded position, the nature of its tissue, and its vascular supply, it is much less often affected with fatal disease than most organs, and is practically exempt from all but a few types of pathological processes. (Among 2,456 deaths from nervous disease, not more than 50 can be attributed to the spinal cord, leaving out the acute meningitis of children.—"Rept. New York City Health Board.") These are acute and chronic inflammations and degenerations. But though organic disease is rare, the cord, being a highly organized tissue, is often subject to functional or nutritional disorders, and to secondary degeneration from brain disorder.

Blood-vessels.—The arteries of the cord are numerous, but are of small calibre, smaller considerably than the veins, and carry blood at a low pressure.

Embolism and thrombosis are very rare, so far as is known, owing to the tortuous course of the arteries, and the capaciousness of the veins. Endarteritis and atheroma are not rare as compared with other organs, but are much less frequent than in the brain. The arterial branches, after penetrating the cord, anastomose with each other but slightly; hence the plugging of a single branch tends to produce softening, as in the brain. But softening may, perhaps, be produced in another way. The small blood-vessels of the cord are richly supplied with vaso-motor nerves, which have a powerful influence over the calibre of the arteries. The result is that by reflex influence, or direct irritation, these arteries may be so tightly closed as to produce complete anæmia, with consequent softening, or they may be so completely paralyzed as to produce minute hæmorrhages and incipient inflammatory conditions. Such, at least, seems to be the mechanism of many cases of acute white softening, of transverse myelitis, and of acute poliomyelitis.

The anterior horns of the cord, which are particularly liable to this latter affection, are supplied each by a branch of the anterior median artery, and occlusion of this would cause suppression of nearly all motor function in one segment of the cord (Ziegler).

According to Stenon's experiments, a stoppage of arterial supply to the spinal cord affects first the gray matter, then the white, and lastly the nerves and muscles. It is evident, from both anatomical and physiological considerations, that the gray matter is most richly and sensitively supplied with blood.

The veins are also numerous, are larger in calibre than the arteries, and communicate with the very rich plexus lying outside the dura mater, which also receives returning blood from the vertebræ, bones, and tissues posterior to these. The spinal cord veins cannot be injected from these large spinal plexus, and passive congestion of the cordes, from obstruction to the general circulation, rarely occurs to such an extent as to cause symptoms.

The circulation of the cord and its functions as a centre are, so to speak, "segmental." The blood flows in, horizontally, through lateral branches of the intercostal, lumbar, or sacral arteries, and flows out through veins at about the same level. Hence it is that acute disorders, which depend so much upon the vascular disturbance, are focal or transverse.

Fibre Systems.—The conducting portions of the cord necessarily embrace long stretches of nerve-fibres, and these must exist in their whole continuity, if at all. If disease attacks one point, cutting off a strand, it extends slowly till it involves a large part of the fibres. Hence chronic diseases of the cord, involving the white matter, always eventually extend up or down the cord.

Regions of Least Resistance to Disease.—For some reason, which is not at present well understood, the upper part of the dorsal cord is particularly liable to be affected in subacute or acute diffuse inflammation. The posterior columns in their lower part are most susceptible to chronic degenerations. The cervical and lumbar enlargements are especially often attacked by the ischæmic softening known as acute anterior poliomyelitis. Of the gray matter, the anterior cornual cells are especially susceptible to slow degenerative atrophy. Hæmorrhages, tumors, syphilitic and tubercular growths, rarely attack the substance of the cord, but take their start in the meninges.

Infections.—The cord enjoys considerable immunity against infections, that of cerebro-spinal meningitis being the only one frequently attacking it. The virus of tetanus, rabies, and of leprosy also especially involve the cord. Syphilis rarely affects it with peculiar growths, but often predisposes it to chronic degenerative and inflammatory disorder. Tuberculosis of the cord is also very rare, and tumors of all kinds, occurring primarily, may be considered pathological curiosities.

Meningeal Disease.—The spinal meninges are subject somewhat frequently to chronic or subacute inflammation; but primary acute spinal meningitis is not very often seen, except as part of the infective cerebro-spinal disorder.

Trauma.—Traumatism causes hæmorrhages, inflammation, and softening, and may start up degenerative processes.

The list of general pathological disturbances of the spinal cord is as follows:

I. *Malformations.* — Myelocele, meningo-myelocele (spina bifida), meningocele, heteratopia, micromyelia, macromyelia, and duplication of cord.

II. *Vascular Disorders.*—Congestion and anæmia, endarteritis, hæmorrhage, aneurism, embolism and thrombosis, œdema.

III. *Syringomyelia.*

IV. *Inflammatory Disorders.*—Acute, subacute, and chronic myelitis, ischæmic and hæmorrhagic softening, acute and chronic meningitis, abscess of cord.

V. *Degenerative Processes of Cells.*—Simple atrophy, fatty degeneration.

Degenerative Processes of Fibres and Neuroglia.—(1) Gelatinous degeneration. (2) Gray degeneration, or sclerosis, primary and secondary.

VI. *Tuberculosis.*—(1) Miliary, without or with meningo-myelitis. (2) Solitary tubercle.

VII. *Syphilis.*—(1) Gummatous. (2) Meningo-myelitis.

VIII. *Tumors.*—Chiefly sarcomata, gliomata, and gummata.

IX. *Diseases of the Meninges.*—External meningitis, internal meningitis of dura, internal meningitis of pia, hæmorrhages, malformations, tumors.

I. Under the head of malformations, or agenetic disorders, should be mentioned a bioplasmic tendency which leads, under slight causes, or simply in the course of development, to degenerative changes of the proper tissue of the cord. An illustration of this is the cord in hereditary ataxia, which is often micro-myelic or deformed, as well as degenerated.

Syringomyelia is also usually associated with, or caused by, some congenital malformation.

Of other malformations meningo-myelocele is the one oftenest observed.

II. Hyperæmia of the cord, so great as to cause symptoms, occurs occasionally as the result of sexual excesses, over-exertion, the stoppage of fluxes, and possibly in the caisson disease. An hyperæmia, affecting especially the meninges, seems sometimes to remain after attacks of meningitis. Spinal hyperæmia, however, of a chronic character, is a doubtful pathological entity, and though the spinal circulation is believed to be sluggish, its course is not easily interfered with.

III. Spinal anæmia is a more real thing. Profuse hæmorrhages, and mechanical obstructions, such as thoracic and abdominal aneurisms, may cause an anæmic paraplegia. Reflex paralysis from intestinal or other visceral injuries is probably due to a spinal ischæmia. Injuries such as gunshot wounds have produced reflex paralyses of presumably similar origin. In general anæmia, when very pronounced, the spinal cord shows some evidence of depression or irritation, but hardly more than do other organs.

After exhausting fevers and depressing traumatisms a paraplegic condition sometimes occurs; it is attributed to spinal anæmia, but probably the condition is more often due to nutritive disturbance. Chronic spinal anæmia can hardly be placed as yet in the category of distinct spinal affections.

Embolism of the spinal cord has been known to occur, but only very rarely. Thrombosis is still more infrequent. Miliary aneurisms, such as develop in the cerebral vessels, are sometimes found in the cord, but they do not, as in the brain, lead to spontaneous apoplexy.

IV. Inflammation is a peculiarly damaging process to the spinal cord; its nervous tissue, once destroyed, has no power of regeneration. Acute inflammation is usually accompanied at first with such exudation and congestion that function is completely and widely suspended. Later, when absorption takes place, the focus of disease becomes more circumscribed and the symptoms lessen. Hence, in acute and subacute myelitis, not ending fatally, the paralysis is usually retrogressive. This is especially the case in myelitis of the gray matter. Chronic inflammation has a tendency, on the other hand, to extend, either by a progress in the inflammation or by setting up secondary degenerations. Hence chronic myelitis causes usually a progressive paralysis. Acute myelitis, after improving, may develop into a chronic form, when we have first retrogressive, then progressive, paralysis. The characteristic changes in acute myelitis and meningitis will be described under the special headings. Inflammation of the spinal cord has this peculiarity, that it is usually necrotic and rarely leads to suppuration or abscess. The initial stage of acute myelitis is often an ischæmic or hæmorrhagic softening. In chronic myelitis the process affects the interstitial connective tissue primarily. As this increases in nutritive activity and anatomical extent, the nerve-fibres and cells atrophy.

V. In degenerative processes, however, the nerve-tissue suffers first, and then the interstitial proliferates. There is thus an inverse ratio in the activities of the two (Gowers). Primary degenerative processes attack, first, the long-fibre systems of the cord and the anterior cornua, throughout more or less of their extent. The primary degenerative process travels both up and down the strand, while secondary degenerations only travel in the direction in which the impulses are carried (Strümpell). Forel shows that in certain pathological conditions which cut the fibre off near its trophic cell, the degeneration extends up to this cell as well as along the peripheral part. After a degeneration is established in one strand, there is a tendency for it to extend to neighboring parts, through proliferation of the connective tissue. The term sclerosis has been used to indicate the condition in chronic myelitis, and also in primary and secondary degeneration. It is used as an equivalent also to gray degeneration. Gelatinous degeneration is a term applied to the earlier stages of the latter process.

VI. For details regarding the rarer conditions of tuberculosis and tumors of the cord, the reader is referred to the special articles. Syphilis appears powerfully to predispose the cord to chronic myelitis and degenerative disorders. The peculiar products of syphilitic development, such as gummata and diffuse gummatous inflammation, are rare. When present they attack, first, the meninges.

General Etiology.—The remarks made upon this head must bear chiefly upon the more common cord affections, viz., inflammations and degenerations. Acute inflammation of the anterior cornual gray matter (anterior poliomyelitis) is mainly confined to children, while acute transverse myelitis belongs to adults. Males suffer more from both forms. Exposure, over-exertion, injuries, and infective fevers furnish the prominent exciting causes. It is not unlikely that a specific infection is the active agent in the acute poliomyelitis or acute ischæmic softening of children. In chronic myelitis there is sometimes, though rarely, a hereditary tendency. Early and middle life, the male sex, syphilis, sexual excess, chronic alcoholism, occupations calling for exposure and over-exertion, are among the chief predisposing causes.

The causes which lead to chronic myelitis are much the same as those that lead to the typical degeneration disease, locomotor ataxia. In ataxia, however, the influence of a hereditary taint and of syphilis is more marked.

Syphilis and lead-poisoning seem to favor the development of chronic degenerations of the anterior horns (progressive muscular atrophy). Alcohol has less influence, pathologically, on the cord than on the peripheral nerves and brain, and it is a minor factor in causing its degenerations. Malaria rarely affects the cord, and then chiefly to produce vascular disturbances of the gray matter. Like alcohol, arsenic causes paralysis, if at all, by producing inflammations of the nerves. Chronic poisoning by ergot may lead to a sclerosis of the posterior columns. In lathyrismus the lateral columns are especially attacked. In certain forms of podagra both lateral and posterior columns degenerate (Tuczec). Hence certain poisons seem to pick out definite physiological tracts. Chronic disorders of the brain, particularly general paralysis, lead often to degenerative changes in the cord; and the brain undoubtedly holds a certain amount of trophic influence over the cord.

Traumatism is an important element in spinal pathology. Severe shocks and blows to the trunk may lead to hæmorrhage (usually meningeal), or excite a chronic myelitis, or lead to the development of degenerative processes. Still more often do traumatism and mental shock, combined, lead to nutritive or functional disorders. It is usually the case, however, in these instances, that the patient has some neuropathic predisposition. It is doubtful if purely mental shock can cause a spinal disorder, though it may lead to a neurasthenic or hysterical condition in which spinal symptoms predominate.

In conclusion, among the remaining causes of spinal cord disease are sudden disturbances of the circulation, such as hæmorrhoidal discharges, suppressed menses, infectious fevers, irritation and disease of peripheral organs.

General Therapeutics.—In the functional diseases of the spinal cord, such as spinal irritation, spinal exhaustion, and the various disturbances associated with hysteria or the morbid diatheses, treatment must always be more of a general than of a special character.

In the scleroses and degenerations specific attempts to affect the nutrition of the cord are attempted. Drugs, diet, rest, counter-irritants, electricity, and mechanical appliances are here used.

The posterior spinal nerves supply directly the skin of the back with sensation. They contain excito-reflex fibres, and by acting on them through the counter-irritants the circulation in the cord is profoundly affected.

The veins carrying blood from the cord join with those supplying the posterior spinal region, and unite with the intercostal, lumbar, etc., veins. By drawing blood from the tissues of the back, therefore, we presumably draw some away from the cord. Hence cupping the back is a favorite therapeutical measure. Slight changes in the spinal circulation are produced by posture, and this is of some importance. Faradic currents act on the cord by counter-irritation; galvanic currents, in addition, reach, and to some extent affect, the cord.

It may be considered certain that strychnia causes a hyperæmia of the cord in large doses; probably phosphorus does the same. Ergot can very probably cause some spinal anæmia, the bromides have a direct sedative power, and iodide of potassium has some resolvent properties here as in other organs. There is ground for believing that mercury has some antiphlogistic powers in acute spinal inflammatory disorders. It would not be worth while to discuss other drugs or remedies here. It will be seen that the spinal cord can be affected by the therapeutist, 1, through the posterior spinal and other excito-reflex nerves; 2, through the efferent blood-vessels; 3, through drugs that directly affect the circulation, the tissue irritability, and the nutrition.

The history of lathyrism, ergot-poisoning, and podagra leads one to hope that we may yet find that certain drugs especially affect certain parts of the cord.

Charles Loomis Dana.

SPINAL CORD DISEASES: ACUTE ANTERIOR POLIOMYELITIS. *Synonyms:* Acute inflammation of the gray anterior horns; acute atrophic spinal paralysis; infantile spinal paralysis; acute spinal paralysis of adults.

Definition.—The disease is characterized by a rapidly setting-in paralysis of various parts of the body, most commonly the lower extremities, preceded, especially in children, by a fever of short duration, sometimes by convulsions, coma, or other nervous symptoms. The paralysis, attended by flaccidity of the muscles, reaches its greatest intensity very quickly, and at the end of a few days begins to decrease. The permanently paralyzed muscles undergo rapid atrophy. In children, when the disease is extensive, there is arrest of development of the bones, and various deformities are produced.

The pathological basis appears to be an acute myelitis, affecting chiefly the anterior cornua.

The clinical appearances of the disease in children were pointed out by Heine in 1840, though its anatomical character was not recognized until a much later period. Since the report of cases by Meyer in 1868, it has been known that the disease occurs also in adults.

Etiology.—The disease occurs chiefly in childhood. According to some observers three-fourths of all cases occur between the ages of six months and two years. It is possible that the liability to disease in early life is due to the yet incompletely developed condition of the spinal cord, especially its motor portions. It occurs chiefly during the summer months. According to Sinkler, 77 of 149 cases appeared in July and August. Sex, heredity, and previous condition of health, seem to exert no influence. External injury, dentition, and exposure are often assigned as exciting causes, but their influence is, at least, doubtful.

The paralysis often appears after an attack of measles, scarlatina, or the like, so that in these cases—possibly this is true of other instances—the disease appears to be produced by a poison circulating in the blood.

Symptoms.—The disease presents a somewhat different appearance in children and in adults, so that it is well to describe each separately.

(a) *Acute Anterior Poliomyelitis of Childhood.*—The paralysis sometimes sets in suddenly, without any prior manifestations of disease; but, more commonly, it is preceded by high fever of a few hours' or days' duration, which may be complicated by various nervous symptoms, as somnolency, or even complete coma. In a large number of cases the disease is ushered in by convulsive seizures. These are like eclamptic attacks, and are of short duration. They may occur in large number, or there may be but a single seizure. The fever in these cases is, possibly, due to the acute inflammatory changes in the cord, but it is singular that such severe cerebral symptoms should usher in what appears to be a purely spinal disease.

The paralysis sets in very rapidly and soon reaches its greatest intensity. When the children are removed from bed, after subsidence of the fever, it is observed that the paralyzed parts hang lifeless, a condition which may at first be attributed to mere weakness. In older children, in whom such observations can more easily be made, the paralysis is usually observed to have come on overnight, or to have reached its height in a few hours, very rarely in several days, while every part affected is paralyzed at the same time.

The distribution of the paralysis is variable. Frequently a single limb, or only a group of muscles, is affected, but more commonly several members are attacked. The paralysis occurs most frequently in a paraplegic form, in the lower extremities, but it may attack the four extremities, and even the trunk, at the same time, or the upper extremities alone. More rarely it occurs in hemiplegic form, affecting a leg and arm of the same side, or even a leg on one side and an arm on the other. The paralyzed muscles are quite flaccid, so that the limbs can easily be moved in a passive manner; the reflexes, both superficial and deep, are abolished.

The paralysis reaches its height very quickly, and from that time the changes are only toward improvement, which takes place, to a greater or less extent, in all cases. The improvement is usually manifest within one or two weeks, and, for a time, progresses rapidly. In rare cases there is complete recovery (temporary spinal paralysis). But in the great majority of cases a greater or less degree of paralysis remains permanently. Of the paralyzed extremities some may entirely recover, while in others, especially the lower, groups of muscles remain permanently paralyzed. The improvement is most rapid during the first six or eight weeks, and then continues very slowly for six or eight months, and, with proper treatment, possibly without it in some instances, the muscles may gain in strength for a year or two.

The profoundly paralyzed muscles soon undergo atrophy. This is usually observed within a week or two. When their power is restored the muscles regain their volume, but in those permanently paralyzed the atrophy may be so complete that no muscular tissue can be felt beneath the skin. The atrophy is sometimes concealed by the accumulation of adipose tissue.

Along with the muscular atrophy are observed changes in the electrical reactions. These are very important, both as diagnostic and prognostic indications. When the paralysis is profound, the faradic irritability of the nerves and muscles is diminished in from three to five days, and entirely abolished in a week. When, on the other hand, at the end of the second week the faradic contractility of the muscles, though diminished, is not abolished, the muscles will not remain paralyzed permanently. The changes in the galvanic reactions are those characteristic of the reaction of degeneration—first, increased galvanic irritability, then anodal closure contraction stronger than cathodal closure—the reverse of the normal formula; finally, the galvanic reactions become weaker and may be abolished. In muscles not so profoundly paralyzed there is usually only a quantitative change in the electrical reactions, a diminution of the faradic and galvanic irritability, but no qualitative change, no reversal of the normal formula of contractions.

The bones and joints are often greatly altered. The bones may be arrested in their development, be much shorter and narrower than the corresponding ones on the other side, and also be more yielding or friable. In this way the whole limb remains smaller than its fellow. This is especially true of the lower extremity, which may be from two to six inches shorter than the sound one; but the arm is also frequently reduced in size, and even the bones of the pelvis are sometimes arrested in their development. The changes in the bone need not correspond to those in the muscles. There may be considerable atrophy of muscles and but little change in the bones, or *vice versa*.

The joints may become deformed and abnormally movable, due partly to atrophy of the cartilages and the epiphyses of the bones, partly to a weakness of the ligaments of the joints. The skin is usually cold and cyanotic, and sometimes becomes dry, liable to indolent sores, etc.

The most characteristic features of the long-standing disease are the various deformities which occur. Various factors play a part in their production. One is the weight of the limb, as when the child lies on its back the paralyzed foot naturally falls into a state of extension, and talipes equinus results. A more important factor is the state of the muscles. The deformity is greater when not all of the muscles of a joint are paralyzed. The limb is then drawn and maintained in its new position by the unantagonized sound muscles, which may subsequently become shortened to adapt themselves to their changed relations. Some other factors may come into play, as retraction of the connective tissue related to the atrophied muscles. In fact, the explanation of the production of deformities is still largely a controversial point.

The most common deformities are the different kinds of club-foot, especially equino-varus. Among others are various contractures of the knees and hips, lateral and antero-posterior curvature of the spine, and contractures of the hands, wrists, and arms.

Apart from those mentioned there are, as a rule, no nervous symptoms. In the very beginning there may be some pain and hyperæsthesia, and weakness of the blad-

der. But these soon disappear, and then there are no sensory symptoms, and the functions of the bladder and rectum are normal. The mind is clear, the general health unaffected, and the patient may live to old age.

(b) *Acute Anterior Poliomyelitis of Adults.*—The disease is ushered in by fever and nervous symptoms, as in children, though convulsions have not been observed. The paralysis sets in rapidly, the paralyzed muscles are flaccid, the permanently paralyzed muscles undergo rapid atrophy, and there are changes in the electrical reactions, just as we found them in children. Less frequently than in children is a single limb affected. Often the four extremities, at least the lower, are paralyzed, though the upper may be alone affected. Improvement soon begins, and, as in children, rare cases of recovery occur. As a rule, more or less paralysis remains permanently. The deformities, which appear at a later period, are not so great as in children, for the bones have attained their full size, and the joints are firmer.

Morbid Anatomy.—The great majority of post-mortem examinations have been made in cases where the disease had existed many years. In these extensive changes have been found in both the white and gray matter of the cord, as well as in the nerves and muscles. But most of these are to be considered secondary changes. In the few cases where an examination could be made at a comparatively early period (after the disease had existed four weeks or longer), evidences of myelitis were found, affecting chiefly the anterior cornua, and, to the largest extent, the cervical and lumbar enlargements. The large ganglion cells were always affected, and their destruction appeared to correspond to the extent of permanent paralysis. It is now generally believed that the paralysis, as well as the trophic changes in the muscles, bones, etc., is due to the destruction of these cells—which have both motor and trophic functions—or to the severance of their relations with the peripheral nerves. The acuity of the inflammatory process accounts for the rapid onset of the paralysis, and the considerable resolution of the pathological process which takes place explains the improvement which is always observed.

The naked eye appearances in recent cases are sometimes negative; sometimes there is indistinctness of outline on section, and discoloration and diminution of size of the anterior cornua. In several instances distinct foci of red softening were found. The seat and extent of the pathological changes are more accurately seen in the microscopical appearances. Foci of disease may be found in various parts of the cord, especially the anterior gray matter, while those of greatest intensity are usually in the cervical or lumbar regions. They may reach for some distance up and down the cord, occupying, at the same time, but a part of the anterior cornua. These are, usually, foci of red softening, in which the blood-vessels are much dilated, and granular cells appear in more or less abundance, and where the nervous elements, large ganglion cells and nerve-fibres, have mostly disappeared. The areas of disease may be distinctly circumscribed, and the neighboring tissues be entirely normal, or a slight and more diffuse inflammation may be observed to extend beyond this in various directions.

Occasionally there is found slight sclerosis of the antero-lateral columns, and diminution of their size, while the anterior roots, those corresponding to the diseased areas, are usually more or less atrophied.

In old cases, where the disease has been extensive, changes are readily seen by the naked eye. The anterior cornua, and often the antero-lateral columns, are much shrunken, and the anterior roots greatly atrophied. On microscopical examination quite circumscribed lesions are usually found in the anterior cornua of the cervical or lumbar enlargements, which are composed mainly of fine wavy connective tissue, with corpora amylacea and pigment granules, and in which the nervous elements have mostly disappeared. If ganglion cells are present they are usually in various stages of degeneration. At the same time the ganglion cells are often reduced in number in other parts of the cord, which may present other slight pathological changes.

In the antero-lateral columns, either in the immediate neighborhood of the greatest changes in the anterior cornua or involving a greater part of those tracts, are evidences of sclerosis, increase of the neuroglia, and atrophy of nerve-fibres.

The muscles present pathological changes corresponding to the intensity of the disease. Sometimes a few normal muscular fibres are found among others which are to a greater or less degree degenerated. In other instances the muscular fibre has altogether disappeared and been replaced by connective or adipose tissue.

More or less degeneration and atrophy are also found in the peripheral nerves, tendons, bones, and joints.

Diagnosis.—Usually a diagnosis is easily made, on account of the striking and characteristic features of the disease. These are flaccidity of the paralyzed muscles, altered electrical reactions, rapidly developing atrophy, and loss of the reflexes, together with absence of sensory or other nervous symptoms.

In young children pseudo-paralysis from disease of bone or other surgical affection might be mistaken for infantile paralysis, but a careful examination, or the lapse of a short period of time, would clear up the diagnosis.

Cerebral infantile paralysis can be distinguished by the absence of pathological atrophy, the normal electrical reactions, presence of the reflexes, the frequent involvement of the intellect, and the hemiplegic form of the paralysis.

The differentiation of hæmatomyelitis, or hæmorrhage into the substance of the cord, will often be impossible. The same is true of some cases of neuritis, though tenderness over the nerve and presence of anæsthesia or other sensory symptoms will usually point to the true disease.

In transverse myelitis there are usually indications of disease of the posterior as well as the anterior part of the cord.

Compression myelitis from Pott's disease presents, usually, the appearance of spastic paralysis, exaggerated tendon reflexes, etc.

Prognosis.—It is possible that some of the fatal cases of convulsions in children were in the initial stage of this disease; otherwise it is not attended by serious danger to life. The prospect is less favorable as regards the paralysis, more or less remaining permanently in most cases. The electrical current is of great value in informing us at an early period as to the probability of permanent paralysis. The information to be gained from it has already been mentioned. The greatest amount of improvement will take place in the first two months. It may be much furthered by proper treatment, and may even continue after a year or more has elapsed.

Treatment.—The early symptoms—fever, etc.—require chiefly rest in bed. Ergot and belladonna have been recommended, on the theory that they limit the inflammation through their influence on the circulation. Applications of ice to the spine, and revulsive applications, have been made for the same purpose. The administration of iodide of potash to promote the absorption of inflammatory products seems appropriate treatment. Electrical applications are often made at an early period. The object of making them, at this time, is to directly influence the spinal cord. For this purpose a large electrode should be selected and applied over the spine, while the other is applied to a distant part, for in this manner the largest quantity of the current may be expected to reach the cord. The positive pole is usually applied to the spine, and as near as possible to the seat of the disease—for instance, to the cervical spine if the upper, to the lower dorsal and lumbar spine if the lower, extremity is paralyzed.

At a later period the current should be applied to the paralyzed nerves and muscles. It must now be looked upon as one of the most valuable agents in treatment. The faradic current is appropriate if it can produce muscular contractions; otherwise the galvanic current should be selected. Duchenne, who was an enthusiast on the subject, believed he could create entire muscles out of a few fibres by means of faradization. At the same time

massage of the muscles, and other gymnastic exercises, should be instituted.

Arsenic and strychnine have been extolled for their power over the paralyzed muscles. Cod-liver oil, tonics, open air, and all else that can invigorate the system are indicated.

During this time efforts must also be made to counteract the tendency to deformity. In this effort the measures already mentioned—electricity, gymnastic exercise, especially the frequent stretching of the retracted muscles—accomplish much. Avoiding positions in which the weight of the limb may cause deformity, sometimes easy walking, holding the joints in proper positions, but not too firmly fixed, may all assist in preventing deformities When the latter are well marked, suitable apparatus, sometimes tenotomy, etc., are called for.

Philip Zenner.

SPINAL CORD DISEASES: ACUTE ASCENDING PARALYSIS.

Synonym; Landry's Paralysis.

DEFINITION.—A rapidly progressing paralysis, usually beginning at the lower extremities, extending to the upper extremities, the muscles of the trunk, and finally to those supplied by the cranial nerves, death often resulting from paralysis of respiration. The paralyzed muscles are flaccid, but there is no special atrophy, and no alteration in the electrical reactions. There are slight, if any, symptoms on the part of sensibility, bladder, or rectum, no bed-sores, and usually little fever. There are no anatomical changes to account for the symptoms.

In 1859 Landry gave an accurate description of this disease, noting, at the same time, the absence of appreciable anatomical changes, and since that time many similar cases have been reported. In 1875 Westphal, in connection with a report of four cases, gave a critical review of the subject. He excluded a number of reported cases in which some anatomical changes were found post mortem, and made an absence of the latter an essential feature of the disease. His views have been very largely accepted.

The absence of anatomical changes in the nervous system has been pronounced by most competent pathologists, such as Vulpian, Cornil and Ranvier, Bernhardt, Westphal, and Kahler and Pick, so that the accuracy of their observations cannot be questioned. But, especially since Westphal's report, a number of cases have been recorded, whose histories are almost or altogether in full accord with those of acute ascending paralysis, in which lesions in the nervous system were found. We must leave it to the future to decide whether the latter do not belong to the same class of diseases, or whether the negative results in earlier cases merely indicate that the pathological changes had not yet progressed far enough, or were not sufficiently intense to be recognized by our present methods of examination.

ETIOLOGY.—The disease occurs chiefly in men, and in adult life. It does not seem to occur specially in those predisposed to nervous diseases. Exposure to cold, suppressed menses, etc., have been assigned as causes. It sometimes occurs in syphilitic subjects, and some have believed, especially on account of the apparent results of treatment, that the disease is sometimes of syphilitic origin, but post-mortem examinations find nothing to uphold this view. It has occurred in the course of, or during convalescence from, acute diseases, as typhoid fever and diphtheria. Westphal believes that some toxic agent causes the disease. In a case of Baumgarten's, where the disease complicated splenic fever, bacilli anthracis were found in the blood and in the cord.

SYMPTOMS.—The disease is sometimes ushered in by shooting pains in the back and legs, sometimes by slight fever, or there may be a general sense of debility and discomfort for some days preceding the paralysis. Numbness and tingling in fingers and toes are not infrequently felt, and this is often the only sensory symptom. The paralysis begins generally in the lower extremities. From a degree of weakness which the patient first complains of, it increases rapidly to complete paralysis. Either at the same time, or shortly afterward, the arms become affected, the paralysis rapidly increasing in intensity. Then the muscles of the abdomen are affected, making defecation, etc., difficult; next, the muscles of the chest, causing respiratory difficulties. Lastly, the cranial nerves are involved, chiefly the hypoglossal and pneumogastric, causing difficult deglutition, indistinct speech, and difficult breathing, the latter often in paroxysms, but occasionally the seventh and other motor cranial nerves are also paralyzed.

The paralysis does not always follow this course. It occasionally begins in the upper extremities, occasionally in the cranial nerves. In the latter case there is usually a very rapidly fatal issue.

The further characteristics of this disease are negative symptoms. The muscles are quite flaccid, but they do not undergo atrophy, at least to any considerable extent, and the electrical reactions remain normal. In a number of instances the patellar tendon reflex was abolished. There are no bed-sores, and no, or at least very slight, disturbance of the bladder and rectum. Sensory symptoms are slight, or altogether absent. Anæsthesia of the soles of the feet, or other parts, has been observed. Usually the general health is but little disturbed, and the mind is unaffected.

The duration of the disease is from a very few days to several weeks, the average being from ten to twelve days. A fatal issue is usually brought on by paralysis of respiration.

But the disease does not always terminate fatally. Of ten cases mentioned by Landry, eight recovered. But there is often room for doubt whether cases that recover really belong to this disease. In favorable cases the disease is usually arrested before it reaches the cranial nerves, though cases of recovery are reported even after the latter have been affected. The progress toward improvement is usually in an inverse order to that of attack, the part affected last being the first to improve. The patient usually remains weak for a long time after the more pronounced paralysis has disappeared. The progress of convalescence is liable to interruptions from relapses, which may even take a serious course.

MORBID ANATOMY.—It has already been stated that, so far as the central nervous system is concerned, the results, in cases generally accepted as those of this disease, were negative. Enlarged spleen, lymphatic glands, etc., as in cases of infectious diseases, were found in a number of instances. This gives some basis to Westphal's view, that the disease is due to a kind of intoxication.

Eisenlohr reported a case (Virchow's Archiv, lxiii., page 73), with almost typical history, of acute ascending paralysis, in which there were slight evidences of myelitis and small capillary hæmorrhages in the medulla oblongata. In a case of Kümmell (Zeitsch. f. klin. Med., ii., page 272), coming on during the convalescence from typhoid, and with a typical history of ascending paralysis, small hæmorrhages in the medulla oblongata were found. Schulz and Schultze reported a case (Archiv f. Psychiatrie, xii., page 457) with the usual symptoms of ascending paralysis, only that the course was a slow one, its whole duration being nearly two months, in which the electrical responses of most of the paralyzed muscles were those of the reaction of degeneration. But the electrical test was not made until about the sixth week of the disease, and, as pointed out by the authors, it is not improbable, if tested in the first or second week, as in other cases, the electrical reactions might have been normal. The post-mortem revealed a fresh myelitis, chiefly of the motor tracts of the cord, of the anterior gray matter, and of part of the medulla oblongata. Lastly, Hoffman (Archiv f. Psychiatrie, xv., page 140) reported a typical case of ascending paralysis, only that there was double facial paralysis, with some diminution of the electrical irritability of the right facial nerve and muscles, though the electrical reactions were elsewhere quite normal. On post-mortem examination a moderately intense meningitis, and slight myelitis, chiefly of the antero-lateral columns in the cervical and dorsal regions, were found. In none of these cases did the extent of morbid

changes appear to correspond to the intensity of the symptoms manifested during life, but they, nevertheless, indicate that those symptoms were dependent on a palpable lesion.

Diagnosis.—The rapidly progressive course, the presence of mostly motor symptoms and normal electrical reactions, will usually distinguish these cases.

Acute multiple neuritis can usually be distinguished by the sensory symptoms, pain, tenderness, anæsthesia, etc., and by the atrophy of muscles and altered electrical reactions. Some cases of subacute anterior poliomyelitis run a very rapid course, so that they closely simulate this disease. But there is greater likelihood of muscular atrophy and altered electrical reactions, bulbar symptoms usually appear at a much later period, and the disease runs a less rapid course.

Acute central myelitis, also, often causes an ascending paralysis, and runs a rapid course. But in this disease the sensory symptoms, anæsthesia, etc., are prominent; there are paralyses of the bladder and rectum, acute decubitus, fever, etc.

Prognosis.—The disease must always be looked upon as a serious one. It is true, cases, apparently of this affection, recover, but in most of these the disease is arrested at an early period. The more rapid the progress of the disease, and the earlier bulbar symptoms appear, the more unfavorable the prognosis.

Treatment.—Cold to the spine, cupping, and blisters have been tried at an early period. Iodide of potash should be administered, especially where there is a syphilitic history. In the latter case inunctions of mercury should also be tried. In Schulz's case hot baths seemed to do much harm, while the constant current to the spine was followed by considerable improvement.

In cases running a favorable course, the use of electricity, hydrotherapy, tonics, change of air, etc., are indicated.

Philip Zenner.

SPINAL CORD DISEASES: ACUTE SPINAL MENINGITIS. *Synonyms:* Acute inflammation of the spinal pia mater and arachnoid; lepto-meningitis spinalis acuta; perimyelitis and arachnitis.

This disease, which is the most frequent and important of the affections of the spinal meninges, is an acute inflammation of the spinal pia mater, with implication to a greater or less extent of the arachnoid, the sub-pia connective tissue, the connective tissue between the pia mater and arachnoid, and the internal surface of the dura mater. As a sporadic affection it is rare, but it is often found associated with lepto-meningitis of the brain, constituting the affection known as epidemic cerebro-spinal fever.

Pathological Anatomy.—This affection may be divided pathologically into three stages: First, the stage of hyperæmia, or commencing exudation; second, the stage of purulent or fibrinous exudation; and third, the stage in which chronic changes are established.

In the first stage, which is seldom observed post mortem, the pia mater appears thickened, opaque, rosy, or dark red in color, and dotted with hæmorrhagic extravasations; the tissues around are swollen from infiltration of serum; the spinal fluid is increased in quantity, and turbid. The sub-pia connective tissue, the arachnoid, the connective tissue between the pia mater and arachnoid, and the internal surface of the dura mater are also congested, the hyperæmia frequently extending to the cord and nerve-roots arising from the affected region.

In the second stage the spinal fluid becomes more and more turbid, and assumes a sero-purulent appearance, containing numerous flakes of fibrin. The pia mater, and the connective tissue underneath the pia, and between that membrane and the arachnoid, become more and more opaque and softened, and are converted into a gelatinous mass by a more or less infiltrated, dense, whitish, fibrinous, or purulent exudation, composed of leucocytes and fibrin. This exudation is more or less resisting, and may appear in lamellæ. Small miliary nodules are found, in some cases, distributed along the course of the vessels of the pia mater, constituting tubercular spinal meningitis. The arachnoid is opaque, and sometimes adherent to the dura mater. The dura mater is hyperæmic, reddened, and opaque, and fibrinous flakes and plates are found adherent to its internal surface. Peripachymeningitic hæmorrhages occasionally occur. The nerve-roots are always involved; they are enveloped in thick masses of exudation, and are swollen and softened. The cord itself is pale, œdematous, or congested, and finally softened in spots or diffusely. Microscopical examination shows in the soft membranes of the cord all the signs of an exudative inflammation—abundant cell-infiltration, especially along the vessels; fulness of the capillaries; swelling and spreading of the bundles of connective tissue, and infiltration of cells in the nerve-roots. The nerve-fibres are swollen, granular, and beginning to break down; the axis-cylinders are swollen and granular, and the bundles of root-fibres entering the cord are similarly affected. In the cord the neuroglia is infiltrated with small cells and nuclei, or actual parenchymatous myelitis is found; the axis-cylinders are enormously swollen and breaking down; the medullary sheaths are cloudy and undergoing granular decay; in the gray substance swelling and œdema of the ganglion-cells occur; the central canal is closely packed with round exudation-cells.

The distribution of the exudation in the membranes varies greatly, both as regards its consistency and thickness and the longitudinal extent it occupies. As a rule, it is circular, covering the whole periphery of the cord, being thicker, however, at the posterior surface of that organ, and it extends the whole length of the spinal canal. The greater thickness of the exudate on the posterior surface has been attributed by some to the fact that the patients lie more on the back. This explanation would not hold good in one of my cases, here reported, where the same thing was observed in a patient who almost constantly lay on his side or face. Others have thought this difference in the thickness to be due to the richer supply of nerves in the posterior region. When the meningitis is limited in longitudinal extent to the length of one or two vertebræ, the inflammation is, as a rule, due to disease of the bone. It is very seldom that the exudation extends upward from the spinal canal to the membranes of the brain, though this has occasionally been seen, as in one of Ollivier's cases and in the second case reported by me.

The third stage, or that in which chronic changes are established, is, of course, only seen in those cases in which acute inflammation gives place to a chronic one. The most common of these changes are opacity and thickening of the spinal membranes, with the formation of adhesions; accumulation of fluid in the arachnoid space (hydrorrhachis); and sclerosis or atrophy, either diffused through the cord or affecting isolated portions or systems. When absorption has taken place, there is, of course, no third stage.

Etiology.—The causes of acute spinal meningitis are still very obscure. It occurs more frequently in the young and aged than in those in middle life, but is not altogether limited to these extremes, a number of cases having been observed in adults. Men seem to be more often affected by the disease than women; but this depends, probably, rather on the fact that they are more exposed to traumatism by the nature of their occupations, and that they are more given to excesses and dissipation, than it does upon any special susceptibility inherent in the sex.

Of the known predisposing causes, the most important are a scrofulous or tuberculous constitution; insufficient food; damp dwellings; sexual, alcoholic, and other excesses, and syphilis.

Omitting the epidemic and infectious influences which affect the occurrence of cerebro-spinal meningitis, with which we are not here concerned, and not considering those cases of extension of the affection from the cerebral meninges to the spinal membranes, as in the tubercular and other forms, the following are credited with having been the exciting causes of this affection in some instances: Injuries to the spinal column from blows, falls,

or railroad accidents, causing either fracture, dislocation, or concussion of the spine; gunshot wounds of the spine, or punctured wounds of the membranes, as in the operation for spina bifida; violent bodily efforts, as in lifting a heavy weight; sacral eschars perforating the dura mater; a sudden fall into cold water; a cold-air current striking the back when the person is sweating; exposure to wet and cold, as from sleeping on damp ground, or standing long in water while working; the suppression of the menstrual and hæmorrhoidal fluxes; suppressed perspiration of the feet; communication of a peripheric neuritis to the spinal meninges, observed in a case of tetanus; dentition; the puerperal state; the opening of an abscess from neighboring parts into the spinal canal; and the extension of inflammation from parts around into the vertebral canal. The following constitutional diseases are known to have been occasionally complicated with acute spinal meningitis: Acute rheumatism; pneumonia; scarlet fever, and the other exanthemata; and pyæmia.

Of these causes the following are rather doubtful: Dentition; the disappearance of acute exanthemata; the suppression of the menstrual and hæmorrhoidal fluxes; suppressed perspiration of the feet.

Symptoms and Clinical History.—In the study of the clinical history of this disease it will be best to divide it into two stages: First, that of congestion and beginning exudation, the irritative stage; and second, that of complete exudation, or compression.

First Stage.—Acute spinal meningitis is only in exceptional cases preceded by the usual symptoms denoting inflammatory action, such as chilly sensations, restlessness, headache, etc. Its onset is generally sudden, a sharp rigor being the first indication of the disease in most cases. This is followed by an irregular fever, and a quick, hard, full pulse. Pain in the back, either confined to a limited region or extending along the whole spine, makes its appearance. This pain, at first dull, soon becomes acute, boring or shooting in character, and is greatly increased by movements of the trunk and limbs; but, as a rule, it is not affected by pressure on the spinal processes of the vertebræ. The pain soon extends around the body, in the form of a girdle, and down the limbs; the alternate passage of a hot and cold sponge along the spine increases it; it is greatest at the site of the principal lesions. In a very short time contraction of the back and limbs is observed, and when the cervical region is involved the head is drawn backward and arched in a condition of more or less complete opisthotonos. Hyperæsthesia and various paræsthesiæ of the skin are well marked. The muscles of the trunk and extremities are also hypersensitive, and the patient remains motionless in bed, with the limbs rigid, not from paralysis, but from fear of the acute pain which accompanies the slightest motion; the muscles are in a state of tension or spasm, which is increased by motion, but not by reflex irritation; there are also spontaneous muscular twitchings, giving rise to severe pain. Dyspnœa, amounting in some cases to asphyxia, is sometimes seen, owing to implication of the respiratory muscles. The pupils are irregular; sometimes they are normal, at other times they may be contracted or dilated, or one of them only may depart from the normal. Violent headaches, vertigo, vomiting, irritation or paralysis of the oculo-motor nerves, together with delirium and coma, are due to invasion of the cerebral meninges. The reflexes, skin and tendinous, are, as a rule, exaggerated in this stage, and there is also exaggerated electrical reaction. Functional derangements of the bladder and rectum appear early in the disease; there is at first costiveness, with retention of urine from spasms of the sphincters of the anus and bladder, then afterward dribbling of urine from overdistention, and later on paralysis of the sphincters. The urine is at first dark, scanty, and cloudy from the urates, but later on it becomes abundant, light, and clear; in some cases an excess has been observed, due probably to direct nervous stimulation of the secretory centres in the cord; in rare cases mellituria has occurred. The abdomen is sunken and tense, and free from meteorisms and swelling; diarrhœa is rare. Eruptions on the skin have occasionally been observed, but not so frequently as in the epidemic form of the disease.

The duration of this stage is variable, lasting from two or three days to a week or more, the disease being occasionally, though very rarely, arrested at this period. At times deceitful signs of temporary improvement will show themselves, but are soon followed by symptoms denoting invasion of the cord or of the meninges of the brain. Death occasionally closes the scene at this period; but this is rare, unless the affection is a sequel to some exhausting disease, or unless the membranes of the brain and medulla are severely affected. As a rule, the symptoms of irritation belonging to the first stage gradually give way to symptoms of paralysis of motion and sensation, denoting compression of the cord and nerve-roots.

Second Stage.—The pains in the back and limbs still persist, but have lost their acuteness; the patient feels dull and heavy; cutaneous and muscular hyperæsthesia are replaced by anæsthesia and muscular paralysis, with contracture and atrophy; the reflexes and electrical reaction become diminished, and sometimes altogether lost; the sphincters of the anus and bladder become paralyzed, and there is incontinence of urine and fæces; more or less paresis, or paralysis, of the extremities exists, the extensor muscles being generally more affected than the flexors; bed-sores and cystitis supervene as dangerous complications. Paralysis of the muscles of deglutition and of the tongue, usually a fatal complication, denotes invasion of the medulla oblongata. Rapidity and irregularity of the pulse and respiration, occasionally observed at this stage, are due to compression of the vagus. The temperature at times rises to 106° or 108° F., denoting extension of the disease to the cerebral meninges; delirium and coma ensue, and speedily lead to a fatal termination, but more often death is brought on by exhaustion and marasmus.

The location of the disease at different levels of the cord naturally causes variations in the symptomatology; as we have said before, it is more common to see the meningitis extending along the whole spinal canal, but at times, in traumatic cases especially, it is more localized.

When the lumbar and sacral regions are alone affected, the pain is felt in the sacrum and loins; the stiffness is limited to the lower part of the spine; the pain radiates to the hypogastrium, perineum, and lower extremities, and the spasms and paralysis are limited to those parts; the urinary troubles are very severe.

When the dorsal region is also involved, the pain and stiffness extend higher up in the back, as far up as the shoulders; there are disturbances of respiration, etc., added to the symptoms manifest in the lower extremities.

When the cervical region is also implicated, there are, in addition, stiffness and pain in the back and neck; excentric pain, extending to the upper extremities; difficulty in breathing and swallowing; derangement of the heart's action, pupillary symptoms, etc.

When the inflammation extends to the medulla oblongata and base of the brain, in addition to the spinal symptoms those of a cerebral nature are observed, such as violent headache, vomiting, vertigo, delirium, trismus, oculo-motor paralysis, disturbances of speech and respiration, and coma.

Some of the symptoms above enumerated are due to the inflammation of the meninges, but the physiological explanation of by far the greater number of these is to be found in the implication of the nerve-roots or periphery of the cord itself, almost invariable accompaniments of spinal meningitis. For instance, the pain in the back, according to Hallopeau, is not due to irritation of the posterior nerve-roots, but is caused by irritation of the meningeal nerves; the spinal meninges have been demonstrated, he says, not to be sensitive in their normal condition, but become extremely so when in a state of inflammation, and he bases his argument on the fact that the pain is almost always absent in myelitis. That irritation of the nerves of the pia and dura mater is account-

able for a certain amount of this pain admits of no doubt, but the very character of the pains—their excentric nature, occurring in portions of the body which derive their nerve-supply from the affected regions of the cord—prove beyond contradiction that irritation of the posterior nerve-roots acts as an important factor in their production. The same explanation must be given for the hyperæsthesia and paræsthesia found in different portions of the body.

The stiffness of the back and extremities, the muscular tension, the contractures and spasms, are due chiefly to direct irritation of the motor apparatus—that is, in part to inflammatory irritation of the anterior roots, in part to irritation of the motor paths in the lateral columns of the cord by secondary points of myelitis. That these motor disturbances are in some cases caused in a reflex manner, by the abnormal irritation of the posterior roots, must be also admitted, as well as the fact that this muscular tension is half voluntary in character, or is increased by a voluntary act which has for its object the prevention of movement when all movements are so painful.

The motor and sensory paralyses, neuralgia, and anæsthesia of the extremities which occur in the later stages of this disease are due to affection of the anterior and posterior nerve-roots, but it is not impossible that myelitic points in the white columns of the cord contribute, in some cases, to the production of this paralysis.

The retention of urine occurring early in the disease is explained by the direct or reflex spasms of the sphincter of the bladder. The later paralysis of this viscus is due to the same causes that produce the paraplegia.

The disturbances of the digestive apparatus and the costiveness which accompany this affection are referred by Koehler to spasm of the intestinal muscles and consequent interference with peristaltic action, and to the spasmodic tension of the abdominal muscles. But to this must be added the sluggishness and weakness which are so characteristic of intestinal movements in spinal diseases.

The disturbances of respiration which occur, from simple accelerated and difficult breathing up to extreme dyspnœa and asphyxia, are due to implication of the cervical roots, causing tension and spasms or paralysis of the respiratory muscles, or to implication of the white matter of the cervical cord, in which are situated the respiratory paths, or to an extension of the disease to the respiratory centre in the medulla oblongata.

The pupillary changes may be due either to irritation of special fibres in the cervical cord or to disturbances of the oculo-motor nerves by extension of the disease to the brain.

The symptoms denoting invasion of the brain have been referred to.

Course, Duration, and Termination.—In the most acute forms of the disease death may occur in a few hours, but more generally it occurs in three or four days, from asphyxia. In less violent cases the duration of the disease is two or three weeks, recovery ensuing at the end of that time in exceptional cases. In other cases the violence of the symptoms is abated, but the patient remains an invalid for a number of weeks or months, improvement in the paralyzed muscles being very slow; and at times contractures and paralysis of certain groups of muscles remain permanent. In other cases, again, the acute symptoms subside and the disease assumes a chronic form, which is usually associated with myelitis, the patient dying, later on, of cystitis and bed-sores.

The following two cases give a clear clinical illustration of spinal meningitis; hence their insertion here.

Case of Acute Meningitis ending in Recovery.—John G——, aged thirty-five, born in England; a machinist by occupation; has been a hard whiskey-drinker for years; smokes and chews to excess; has never contracted syphilis; gives no history of hereditary predisposition. About June 16, 1883, he went on a spree, and slept all night on the ground in one of our public squares, where he was picked up by the police next morning. The day previous had been a very rainy one, and the ground, on which he must have lain for hours, was quite wet. When aroused he felt stiff in the legs, but was able to accompany the officers to the jail, and on that same day he was discharged by the police-court and was admitted into Charity Hospital, in the ward for nervous diseases, complaining of great pain of a shooting character in the lumbar and dorsal regions of the spine. The pain extended all around his body at the level of the nipples, and shot down the legs; these felt numb and stiff, but he was still able to stand; his pulse was hard, full, and fast, about 104 per minute; his respiration somewhat accelerated, and his temperature 101½° F. I saw him on the next day, and made the following notes of his case: Patient is well nourished; general appearance good; complains of sharp, shooting pains along the spine, from the neck down, extending around the body and around the arms and down the legs; this pain is not increased by pressure on the spinous processes, but the slightest movement of the body or extremities brings on an exacerbation; the back is stiff and arched, and the legs flexed on the thighs, and the thighs on the pelvis; he is unable to extend the extremities, not that any paralysis exists, but from the fact that the attempts at motion give rise to severe paroxysms of pain; the muscles in the trunk and extremities are tense and contracted, and the patient complains at times of involuntary twitching, giving rise to exquisite pain; his bowels are constipated, and he has passed no urine since admission. With a soft catheter over a pint of highly colored urine was drawn from his bladder. The pulse is 112, full and hard, and the temperature has reached 102° F. The patient's mind is clear, and, aside from some frontal headache, he complains of no disorder about the head. A brisk purgative of calomel and bicarbonate of soda, each fifteen grains, was prescribed, and cold applications were made to the back, the patient being ordered to lie on the side, which position he had, however, already assumed of his own accord. Quinine sulphate, in five-grain doses, was also given every four hours, and a tablespoonful of the following mixture after each dose of quinine: Fluid extract of ergot, ʒ iv.; potassium bromide, ʒ iv.; syrup of orange-peel and water, each ℥ iij.

On the 18th the patient was found very restless; the pains still continued to be intense in the back and lower extremities, which were found still more stiff, the hands and arms felt numb, and he complained of shooting pains also in these. The bowels had acted several times, but his urine had to be drawn, the slightest effort to pass water being accompanied by excruciating pain; the patient's position was that of opisthotonos. The temperature was 102° F., pulse 110. The mind was clear; there was no vomiting; respiration hurried, but otherwise normal. The same medication was continued, with five drops of Batley's sedative added to each dose of bromide of potassium.

During the next week the patient rested somewhat better, but there was no improvement in his symptoms; the urine was still retained; the disease, however, seemed to have made no noticeable progress. A considerable quantity of milk and several eggs were taken, and retained, every day; the temperature oscillated between 101° and 103° F., with no uniform remission. On the seventh day the quinine and Batley's sedative were stopped, the bromide and ergot continued; a saline purgative—Glauber's and Epsom salts, each ℥ ss.—was given, and the cold applications to the back were replaced by applications of tincture of iodine along the spine.

The patient's condition was now as follows: Pain somewhat diminished, but back and extremities feel stiff, numb, and heavy; sensation to touch and pain, tested in hands and feet, is blunted and retarded; patient finds considerable difficulty in moving his legs and arms, but when these are moved the pain in the back is not so greatly increased as on the previous days. The urine is still retained, and dribbles from him unawares; his bowels have not acted since the second day. On July 8th, the twentieth day of the disease, the temperature has for the first time fallen to normal; the pulse is weaker and faster, 120 to the minute; the urine still dribbles, and has to be withdrawn; the bowels have acted several times since last account; the pain and stiffness in the back are still present, but bearable as long as the patient remains at

Spinal Cord.

rest; the paresis and anæsthesia of the lower extremities are almost complete, and the patient complains of burning and creeping sensations in these parts; there is a slight wasting of the muscles; the skin over the sacrum is reddened, and a bed-sore is feared. The upper extremities are numb and weak, but the patient is able to move them slowly. Counter-irritation, by means of tincture-of-iodine applications to the spine, is still kept up, and all medicine, except the following, discontinued: Potassium iodide, gr. v.; potassium bromide, gr. x.; four times a day.

On August 12th the patient is able to sit up in a chair; the dribbling of urine has stopped, and the bladder is slowly evacuated by natural means; the bowels, though sluggish, act without assistance; the back and lower extremities are as yet stiff and a little painful, but the patient has obtained some control over the latter and is able to move them slowly; the wasting has not progressed; sensation is evidently better than at last report; the upper extremities have improved; there is a superficial sore over the sacrum, which, however, shows healthy granulations. The potassium iodide, in ten-grain doses, three times a day, is still continued; daily mild galvanic currents, alternately ascending and descending, are applied to the spine, and the muscles of the lower extremities are faradized; the faradic irritability is somewhat diminished.

At the end of September the patient was able to go about unassisted, and was discharged, cured, on October 10th, nearly four months after admission, nothing but a slight stiffness of the back and lower limbs remaining.

Case of Acute Spinal Meningitis, with Cerebral Complications, ending fatally on the Ninth Day. Autopsy.—A. P——, white, male, aged twenty-three, was admitted in the ward for nervous diseases in Charity Hospital, under my care, complaining of acute pain in the spine, extending from the head to the sacrum. The back was considerably stiffened, and the lower extremities were drawn up; the pain also extended to the trunk and all four extremities, and, though continuous, would be considerably increased at times; pressure over the vertebræ seemed to give rise to no exacerbation of the pain, but the slightest motion of the spine, either backward or forward, would cause the patient to scream with agony; there was considerable hyperæsthesia of the legs and arms, and pressure on the same gave rise to immediate complaint; the muscles of the extremities were contracted; the urine dribbled away, and the bladder was full; the bowels were costive; temperature 103° F.; pulse hard, full, and 116 a minute; respiration jerky, 24 to the minute. The patient said that he had been taken with uneasy feelings and weakness in his back and head three days ago; that this had so increased the following day that he was forced to keep his bed, when a chill, followed by fever, came on. He was occupying a bed on the fourth floor of a boarding-house, and on the third day, as the symptoms seemed to be aggravated, he requested to be taken to the hospital.

After admission a saline purgative was administered, cold applications to the back were immediately begun, and quinine was given to reduce the temperature, and sedatives, such as opium, bromide, and chloral, used to soothe the pain. On the two following days the patient's symptoms were found more severe; the pains in the back and limbs were excessive; the opisthotonos was complete; the urine was passed involuntarily, and the patient had had two unconscious motions from the bowels in bed; the temperature was 104½° F.; the pulse very rapid, soft, and irregular, 124 to the minute; and at times there was considerable delirium of a most violent kind. On the next day—the sixth of the disease—the patient's condition was found considerably aggravated; the delirium, though milder, was almost continuous; and other troubles, such as vomiting and eructations, were frequent; the respiration was rapid and labored, 32 to the minute, and deglutition was difficult; the pulse was scarcely perceptible; paralysis in the extremities had supervened, and the skin reflexes were almost entirely abolished. The patient's condition continued to grow worse, the delirium passing into coma, which ended in death on the ninth day of the disease, and the sixth day after his admission to the hospital.

Autopsy, held five hours after death, revealed a congested and œdematous condition of the lungs; heart full of fluid, dark-colored blood; other organs normal. Spinal marrow: Along the whole spine the internal surface of the dura mater was rosy; blood-vessels very much enlarged; opposite the lumbar enlargement, particularly, there was a slight fibrinous deposit on the internal surface of that membrane; the arachnoid was opaque, but showed no other evidence of disease; the spinal fluid was very abundant and sero-purulent; on the surface of the cord and in the meshes of the pia mater was a thick fibrinous deposit, which enveloped the whole cord and the nerve-roots; this deposit was thicker posteriorly, and diminished in density from below upward to the medulla, where it was very thin; the marrow was pale, and in some localities (at the lumbar and cervical enlargements) a little softened. At the base of the brain, and over the Sylvian fissure on both sides of the convexity, a thin exudate of fibrin was found; the cerebral fluid was increased, and the blood-vessels of the brain were much congested. The cord was preserved, by hardening, for microscopical examination, but, unhappily, the Pathological Department of the hospital was being rebuilt at the time and the specimen was lost.

This case, if we are to judge by the amount of post-mortem changes and the development of symptoms, was undoubtedly one of inflammation of the spinal meninges, progressing upward and implicating, secondarily, the cerebral meninges. As to its cause nothing could be ascertained, the patient being a laborer who had been out of work for some time; he was of temperate and regular habits, and had never had syphilis; he had received no blow and suffered no fall; he gave no history of hereditary predisposition to tuberculosis, and showed no evidence of this disease in any of the organs examined.

Diagnosis.—The diagnosis of acute spinal meningitis must be based on its sudden onset and the severity of its symptoms. The distinguishing signs, aside from fever and other general symptoms, are sudden, acute pain in the back, extending to the trunk and limbs, increased by motion, but not affected by pressure over the spine; rigidity of the back and extremities; hyperæsthesia and paræsthesia of the skin and muscles; retraction of the head; difficulty of breathing and swallowing; retention of urine and constipation; normal or exaggerated reflexes.

Dorsal muscular rheumatism is distinguished from spinal meningitis by the character of the pain, which is confined to the back, the absence of general and spinal symptoms, and its usually favorable termination.

Tetanus may be differentiated by the fact that the trismus appears first in that disease, by the absence of fever in the beginning, by the absence of hyperæsthesia, and by the fact that the exacerbations of pain and the spasms are brought about by peripheric irritation.

Myelitis can be recognized by the early and deep motor and sensory paralyses, and by the absence of stiffness in the back and neck, of the excentric pains in the limbs, and of hyperæsthesia of the muscles or skin, which characterize, especially, meningitis.

The diagnosis of tubercular meningitis must rest on general considerations, and on the association with basal cerebral meningitis.

Prognosis.—Acute spinal meningitis is always a grave affection; hence our opinion should always be guarded. When the symptoms are in general mild, the fever not very high, and when there is no extension to the upper portion of the cervical cord, in an otherwise strong and healthy individual, the outlook is more encouraging, but we should not be too hurried in prognosticating favorably.

Hyperacute and tubercular cases, or those caused by deep bed-sores, are nearly always fatal. Rheumatic and traumatic cases, when the lesions are moderate, are more favorable. Symptoms which show that there is early compression or implication of the cord itself, such as paresis or paralysis, twitching of the limbs, muscular

contractures, and anæsthesia of the skin, are generally unfavorable, as are also a high fever, progressive rise of temperature, extreme frequency and irregularity of the pulse, great difficulty of breathing, early signs of exhaustion, severe cerebral symptoms, and signs of implication of the medulla oblongata. The disease is also much more liable to terminate unfavorably in the very young and in the aged.

TREATMENT.—We know at present of no remedy that will act as a prophylactic in spinal meningitis; the avoidance of such of the causes as are known to have brought on the disease are, however, here to be recommended.

In the first stage of the affection our attempts should be directed to the reduction of the hyperæmia in the parts, and the moderation of the general symptoms; for this purpose the local abstraction of blood by cupping along the spine, the application of leeches to the neck, back, and perineum, cold applications to the back by means of ice-bags, the internal administration of large doses of fluid extract of ergot or ergotine and tincture of belladonna, are to be recommended, and have been found occasionally of benefit. The patient should be put in a quiet, airy room, and should rest on the side or face; antipyretics, such as quinine, salicylate of sodium, antipyrine, and antifebrine, should be used, if indicated, to lower the temperature; a brisk mercurial purgative, followed by salines, is also of use to cause derivation to the intestines. If the disease is of rheumatic origin, free, energetic diaphoresis will be of benefit. If the pains are very severe, sedatives, such as bromide of potassium, chloral hydrate, the preparations of opium and of hyoscyamus, or the moist pack, are indicated. To limit the amount of effusion, mercurial inunctions are considered of benefit. To relieve the retention of urine, the catheter should be regularly used.

When the disease has passed into the second stage all depressing medication must be stopped; the patient is to be well nourished, and tonics and stimulants are to be freely given. Absorbents, such as iodine, or the iodide of potassium, and ergot, in full doses; mercury, in small doses, internally and externally, in the form of an ointment; and counter-irritation along the spine, by means of tincture of iodine or otherwise, are to be used. Warm baths and moist packs are of marked utility. The use of sedatives is to be continued if required. The urine is to be attended to. The sequelæ, such as paræsthesia, anæsthesia, and the various motor disturbances, are to be treated by means of baths and the judicious use of the galvanic and faradic currents to the spine and affected parts. Care must be taken during convalescence to avoid all fatigue and bodily exertion.

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SPINAL CORD DISEASES: CHRONIC SPINAL MENINGITIS. DEFINITION.—Chronic lepto-meningitis is an inflammation of the soft membranes of the spinal cord, unaccompanied by fever, slow and gradual in its evolution and course, which either develops spontaneously or follows acute inflammation of those parts. The symptoms, which are generally at first trifling, may gradually assume a more severe character as the inflammation extends from the membranes to the cord itself.

PATHOLOGICAL ANATOMY.—The lesions of chronic spinal meningitis are constant as regards their nature, though differing widely in intensity and extent in different cases, the changes being often only microscopic. On opening the spinal canal the spinal blood-vessels—the veins and capillaries mainly—are found congested, full of a dark-colored blood; the membranes, especially the arachnoid and pia mater, are hyperæmic, opaque, and more or less thickened and adherent; there are often adhesions between the pia mater and the cord, and between the former and the dura mater; the spinal fluid is abundant. The thickening of the soft membranes may be so great as to appear cartilaginous, and they may be pigmented in spots and present small points of extravasation of blood. Numerous small plates of calcareous matter are generally found upon the arachnoid, especially in the lumbar region. The dura mater is, as a rule, involved in the inflammatory process, and shows more or less marked congestion, opacity, and thickening. The extradural connective tissue also frequently participates in the process. Sometimes small granular growths of connective tissue may be found on the internal or external surface of the dura mater.

As a rule, the cord and nerve-roots are implicated to a varying degree and extent. Besides the degenerative changes occasionally induced by compression from the thickened membranes on that delicate organ, the processes which penetrate the spinal marrow from the pia mater are also thickened and swollen; at other times this inflammatory process spreads to the neuroglia of the cord, and we have then a true sclerosis in different regions and varying in extent, sometimes affecting the whole periphery of the cord and causing the usual secondary degenerative changes in the nervous elements in the posterior and antero-lateral columns; the changes occasionally extend to the gray substance and nerve-cells, whence results an atrophy of the cord.

The nerve-roots arising from the affected region are usually compressed, atrophied, and degenerated, and this atrophy and degeneration, as a rule, extend to the peripheral nerves and muscles. As sequelæ bed-sores and cystitis develop.

ETIOLOGY.—Chronic spinal meningitis very often follows the acute form, in which case its causes are the same as those of the latter.

As predisposing causes must be mentioned all debilitating influences; the abuse of alcoholics and tobacco; syphilis; chronic diseases of the heart, lungs, liver, and all conditions that give rise to impeded circulation in the vertebral and spinal veins; also sexual or other excesses.

Among the exciting causes must be mentioned frequent exposure to cold; the inhabiting of damp dwellings; constant exposure to bad weather; sleeping on damp ground; the abuse of alcoholics; the suppression of certain discharges of long standing, such as the menses, hæmorrhoids, sweating of the feet; and finally, traumatisms of moderate intensity, such as shocks, falls upon the buttocks or back, railway accidents, excessive bodily exercise, the lifting of heavy weights when the body is in an unfavorable position, etc. The disease may also be excited by the presence of chronic inflammatory processes or neoplastic growths of neighboring parts, which may pass to the meninges or excite a constant irritative action upon them; among these causes may be mentioned periosteitis, or caries of the vertebræ, chronic inflammation or sclerosis of the cord itself; tumors of every nature in or around the spinal cord, syphilis, and leprosy.

SYMPTOMS AND CLINICAL HISTORY.—The semeiology of chronic spinal meningitis has not been sufficiently studied, by reason of the fact that the disease is complicated with other affections which more or less effectually mask its symptoms. Its symptoms are, however, very similar to those of the acute form, but slower in development. In some cases the disease follows directly upon the acute form, in other cases several successive attacks of subacute meningitis develop gradually into the chronic form from want of proper precautions being taken during convalescence, but more often the disease is chronic from the very beginning, and insidious in its development. The first symptoms are usually abnormal sensations, as of weight in the lower limbs, with pain and stiffness in the back gradually increasing. This pain is at first not severe, it is never increased on pressure, but is aggra-

vated by motion of the vertebral column or by the alternate passage of a hot and a cold sponge along the spine; this is accompanied by excentric sensations, such as the feeling of a girdle round the trunk and boring or shooting pains down the extremities along the nerves arising from the affected region. The extremities feel heavy and weak, and a number of abnormal sensations, such as prickling, tingling, formication, numbness, etc., are present, varying in degree during changes in the barometric and thermometric conditions. These sensations are always more marked in the lower extremities. Along with these sensory disturbances symptoms of motor irritation also develop, but they are, as a rule, of subordinate importance; stiffness of the back and neck when the disease is situated high up; trembling of the extremities, sudden startings, muscular twitchings, jerking and involuntary drawing up or extension of the limbs, and gradual weakness, going on to paralysis, with loss of control over the extremities. The tendon and skin reflexes are sometimes normal, more often diminished or absent, rarely exaggerated. From the beginning there is always some disturbance of the functions of the rectum and bladder; the patient complains of costiveness, which only gives way to purgatives, and of difficulty in emptying the bladder, with some dribbling of the urine. The electrical irritability is at first diminished, and afterward altogether lost.

These symptoms fluctuate greatly, being worse in some cases one day than another, and in others being aggravated by the standing position; in the latter cases the accumulation of spinal fluid is probably excessive. In other cases, again, lying down on the back aggravates the symptoms; this is probably due to increase of the passive congestion occasioned by that position.

As time rolls on, the disease progresses; the pains and stiffness of the back become aggravated; the paræsthesia slowly gives way to anæsthesia, more or less complete; paralysis and atrophy succeed to the weakness of the limbs, so that the patient is bedridden. The bladder and rectum become completely paralyzed; cystitis and bed-sores are developed, and the patient dies of exhaustion or marasmus, unless he is sooner taken off by some acute complication.

Exceptionally an acute attack supervenes upon a chronic one, which has lasted for years, and rapidly puts an end to the case; but more frequently the disease drags on for years, with occasional temporary improvement and retrogression in the patient's condition, as described above. Occasionally, after a long lapse of time, the patients recover, with or without treatment; but, as a rule, this recovery is seldom altogether complete, and more or less impairment of function remains, in the form of atrophy or contracture of certain muscles or groups of muscles, etc. In very rare cases a complete and lasting cure is obtained.

The following cases will serve to illustrate the symptoms and course of the disease:

C. D——, white, male, aged thirty-seven, applied for treatment at the out-clinic department of Charity Hospital, in September, 1883, and was referred to my service. He gave the following history: By occupation he is a painter, but he has done no work for a year, on account of ill health. He is married, and of late years has been very temperate in his habits, not drinking at all, and using tobacco moderately; for ten years of his life, from the age of twenty-one to thirty-one, he drank rather freely, mostly whiskey of an inferior quality; he has never had syphilis; his family history shows no tendency to nervous or tubercular disease; he shows no sign of inherited syphilis, and, up to the beginning of his present ailment, he has been all his life in fair health. He has never had any symptoms of saturnine poisoning, either acute or chronic, and examination fails to reveal any of the signs of the toxic effect of this metal. About eighteen months previous to his admission to the hospital he felt, on getting up in the morning, a peculiar numbness and tingling feeling in both his lower extremities, and especially in his feet; this he attributed, however, to some abnormal position assumed during sleep, and went out to his work, as usual, returning only in the evening, when he felt altogether himself again. This feeling, however, returned on the following two or three mornings, accompanied by a dull, stiff sensation in the back, about the lumbar region; it became more and more persistent, so that by the end of a week it did not leave him during the whole day, and interfered with him in his work. He went to consult his physician, who told him he had taken cold, and gave him a plaster to apply to his back, a liniment to rub his extremities with, and a tonic to take internally, and said everything would be right in a few days. Not finding any relief after two weeks' treatment under his family physician, he was prevailed upon to consult another physician, under whose care he remained for several weeks, the symptoms becoming all the time aggravated, but not being of sufficient importance to force him to relinquish work as yet. About two months after he was first attacked he noticed that something was wrong with his urine, which he passed only in a small stream, and while at work a few drops would occasionally dribble from him. About that time also his bowels, which had always been very regular, became somewhat costive, and he was forced to make use of aperients frequently. Alarmed at this, he again changed medical advisers, and upon the advice of his newly chosen attendant refrained from work and remained at home, a great deal of his time in bed, for several weeks. Under this treatment he gradually improved, and at the end of that time was again able to return to his occupation. He remained better, however, only a short time, for the pains soon returned, but sufficiently severe this time to force him to rest of his own accord; the dribbling of urine became worse, and the numbness and tingling were continuous, even when he was in bed. After several weeks of rest he attempted to resume work, but could not. His legs felt heavy, he was unable to stand on them long, and the pain and stiffness in the back were worse, and had also invaded the legs; his urine continued to dribble, and he had to empty his bladder every hour or two during the day and night. This condition grew slowly worse up to the time of his admission into the hospital.

Upon my advice he remained as a patient in the hospital for two months, undergoing treatment, which consisted of mild galvanic applications to the spine, faradization of the extremities, and ten grains of potassium iodide, internally, four times a day, besides which he took, morning and evening, thirty drops of fluid extract of ergot and ten drops of tincture of belladonna. At the end of that time the following notes of his case were taken: Lancinating pains in back, extending from the middle dorsal region to the sacrum; pains extend around the abdomen and down the anterior and posterior aspects of the legs and thighs; stiffness of these regions; the pain and stiffness are increased by active motion of the spine and limbs, but there is no tenderness of the back, and no change in the symptoms is caused by motion of the body; his legs feel numb and heavy, and he occasionally suffers from formication; his gait is uncertain and tottering; tactile sensation is diminished in the lower extremities, but sensation to pain is about normal; the patellar reflex is a little exaggerated; electrical sensibility and irritability are diminished, but there is no reaction of degeneration. The muscles of the limbs are well developed and in a state of constant tension; the patient's general health is good, his appetite is good, body well nourished, and the cerebral functions are well performed. His upper extremities feel somewhat numb, but are otherwise normal; he suffers still from dribbling of the urine, and has frequent calls for micturition; he has occasionally passed his urine unconsciously in bed during sleep; the bowels are costive, requiring the frequent administration of purgatives and enemata; his abdomen is tense; the other inorganic functions are well performed.

At his own request the patient was discharged in this unimproved condition, and since then nothing has been heard of him.

A Case of Chronic Spinal Meningitis, of Six Months' duration, following an Acute Attack, resulting favorably after

Six Months' Treatment.—A. M——, white, male, aged twenty, a clerk by occupation, is well nourished, of temperate habits, never drinks, but smokes occasionally; he has indulged in sexual excesses for the past year. There is no hereditary history of disease; the patient has never had syphilis, but has had malarial intermittent fever frequently, lasting weeks at a time, during the last few years. Six months ago he fell from a horse and struck his back in the lumbar region; he was stunned, and remained unconscious for some time, and had to be carried home. He felt very sore in the back after the accident, but could move his legs and body, and had no difficulty with the bladder or rectum. After being taken home he was examined by his physician, who pronounced the injury trivial, no bone being broken or out of place, but advised his remaining in bed for some days.

The next day the patient, feeling better, got up and went about the house; two days after this he was taken with severe pain in the back, in the region where he had received the injury; the pain, he says, spread around the body like a belt, and shot down the thighs and legs; it was so severe that he had to go to bed. The next day a high fever developed, and the pain continued to increase, his back and lower limbs being also very much stiffened, so that he could not be moved without experiencing excruciating pains, and his urine had to be drawn. He was immediately put under treatment, and in a fortnight the fever had subsided, and the pains had diminished, but he had strange feelings, as of ants crawling, and numbness down the legs, which latter were almost completely paralyzed; he had lost control over his water, and his bowels were very much constipated. He remained pretty much in this condition until his admission into the ward for nervous diseases, of Charity Hospital, in December, 1885. He was immediately placed under treatment, large doses of bromide of potassium and chloral being given at first to relieve the pain, which had again become more acute in the back and lower limbs. In two or three weeks electricity was applied, when the reaction to the galvanic current was found diminished, but in the normal formula; the tendon reflexes were found subnormal; regular electrical applications were begun at that time, potassium iodide in five-grain doses, three times a day, was ordered, and the patient's bladder and bowels were attended to. Improvement was perceptible in a very short space of time, and six months after admission, in July, 1886, he was discharged, thoroughly cured, no untoward symptoms remaining. The patient was seen a few weeks ago, and it was ascertained that he had remained completely well since his discharge from the hospital.

DIAGNOSIS.—Chronic spinal meningitis is, as already mentioned, at times difficult to recognize, on account of the insidiousness of its beginning, and masked as it is by important complications; for its diagnosis we must rely on the pain and stiffness in the back, the paræsthesia of the extremities, and on the mildness and uniformity in distribution of the paresis, and the general absence of increased reflex action, of obstinate contractures, of atrophy, and of painful muscular jerkings, and on the modification of the symptoms generally caused by change in the position; all of these are characteristics of this disease and serve to differentiate it from myelitis, in which the paralysis and anæsthesia are severe, the contractures well marked and lasting, the muscular atrophy of paralyzed limbs noticeable, and the reflexes exaggerated, and in which the pains in the back and extremities, with stiffness of the spinal muscles, are absent.

From anterior poliomyelitis the characteristics of this disease, paralysis and atrophy, with no disturbance of sensibility, and absence of pain, are sufficient diagnostic signs.

Tabes dorsalis may be recognized by its accompanying fulgurating pains, ataxia, and disturbances of muscular sensibility. We must remember, however, that both affections are often combined.

Spinal irritation occurs in young women, as a rule, and is accompanied by symptoms of hysteria; its onset is sudden, and not always free from fever; there is hyperæsthesia of the spine, but no stiffness; there is tenderness over the spine rather than real pain, and the fluctuations in the intensity and character of the symptoms are marked. The severity of the subjective symptoms is also in striking contrast with the mildness of the objective appearances; there are no signs of organic disease of the cord; other signs of hysteria and of ovarian and uterine diseases are common.

PROGNOSIS.—The prognosis of chronic spinal meningitis is always serious; a cure is hard to obtain, and is generally exceptional in old and tedious cases; but improvement and cure have occurred even in what seemed at first hopeless cases, so that the prognosis must be guarded, and treatment should be persevered in for a long time, even in severe cases.

Sometimes, without apparent cause, the inflammation will become limited and the work of repair begin. The amount of improvement to be expected, then, depends essentially on the extent of the organization, calcification, or retraction of the effused material, and on its absorption. But even after the changes in the inflammatory products seem to be at an end, and the case has remained stationary for a long while, further improvement in the functions may occasionally be obtained in the course of time by means of judicious treatment.

Before making a prognosis the following conditions must be taken into account: The patient's age, constitution, and powers of resistance; the state of bodily nutrition; the causes which have brought on the disease, and the possibility of their removal; the amount of structural changes which have taken place in the spinal canal; the amount of myelitis and other complications, as shown by the intensity of the symptoms; and finally, the improvement brought about by previous treatment.

We must not, however, be too sanguine in our prognosis and lead the patient to expect too much.

TREATMENT.—In order to prevent the occurrence of this affection, great care should be exercised during convalescence from the acute form of the disease; all predisposing causes should be carefully looked after, and the exciting causes removed when possible.

As to the treatment proper, our attempts should be directed to the limitation of the disease, the relief of annoying symptoms, and the prevention of avoidable complications. For the first purpose, counter-irritation to the skin, especially along the spine, is useful; this is best accomplished by blistering, the application of tincture of iodine, turpentine, croton-oil, or other epispastics, and the use of dry cups. Antiphlogistics are rarely required, except in plethoric individuals with unusually severe symptoms, pointing to an invasion of the cerebral meninges; the same may be said of the wet cups and of profuse purgation for the purpose of bringing on intestinal derivation; at most, mild laxatives will be of use. Inwardly, iodine and the iodides in moderate doses, continued for a long while, with mercury in syphilitic cases; ergot and belladonna are often employed, but have been found of little or no benefit. Diuretics are of some utility in cases of abundant serous exudation. Warmth, externally, with stimulating frictions and massage to the affected limbs, has occasionally been serviceable.

To fulfil the second indication, an abundance of good, nourishing food, with an occasional stimulant, is required; tonics, such as quinine, iron, and the compound hypophosphites are necessary to combat the anæmia and debility which generally coexist with the disease.

For the relief of distressing symptoms, sedatives, such as opium and hyoscyamus, chloral, and the bromides are used for the quieting of the pain; for the same purpose, in obstinate cases, warm baths and baths of all sorts, wet packs, and alternate cold and warm water douches are also of service. A stay at one of various mineral springs will be of benefit in some cases to relieve the paresis and paræsthesia; stabile ascending and descending galvanic currents, of moderate intensity, and faradism to the affected muscles will also be of use in the same direction. For the rectal and bladder troubles, aperients, regularly administered, ergot, nux vomica, and electricity are of service.

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SPINAL CORD DISEASES: CONGESTION OF THE CORD. Our actual knowledge regarding spinal congestion is very limited, and hypothetical statements that it is the basis of many nervous symptoms are unwarranted. The diseases in which it is uniformly found after death are those in which the patient has died in convulsions complicated by asphyxia, or in the early stages of myelitis. The only positive evidence that a spinal congestion has existed during life is the discovery of distended capillaries, accompanied by small capillary hæmorrhages. Without the latter the congestion found may have been a post-mortem occurrence, due to the position of the body on the back.

The *causes of active congestion* are excessive muscular exertion, violent sexual excesses, poisoning by strychnia, alcohol, and carbonic oxide, the sudden arrest of menstruation or the stoppage of hæmorrhage from piles, and possibly exposure to cold. Traumatism of the vertebræ, especially general concussion of the spine, such as occurs in railway injuries, probably causes active spinal hyperæmia, in a few cases examined capillary hæmorrhages having been found after death in the cord. It is probable that spinal congestion is usually localized in the lower half of the cord, though the entire organ may be affected. An active hyperæmia of the anterior cornua is the first occurrence in poliomyelitis anterior, and this is usually quite extensive, while the actual process of inflammatory degeneration is subsequently limited to a small area. The latter produces the permanent atrophic paralysis of infants; to the former must be ascribed the temporary paresis of the first stage of the disease, which is always more extensive than the permanent paralysis.

The causes of passive congestion are the same as those producing this effect in the brain or other organs (*q.v.*).

The *symptoms of spinal congestion* are a sensation of weight and fatigue in the legs and back, increased by any effort, so that continued exertion is impossible; pains, numbness, formication, and sensations of heat and cold, with increased susceptibility to changes of temperature and to pain and touch in the extremities; weakness, but not paralysis, in the entire muscular system, attended by an increase of reflex excitability; a diminution of sexual power; and a diminution of control over the bladder and rectum not sufficient to be termed incontinence. Any symptoms more serious than these, such as severe tearing pains in the back and general hyperæsthesia; or such as girdle sensations, incontinence, and actual paralysis, must be ascribed to congestion of the spinal meninges as well as of the cord, or to disturbances of a grave nutritive kind initial to an actual myelitis. These symptoms are always bilateral, and usually more marked in the lower half of the body, although the arms may become involved. They usually come on suddenly after some known cause; but occasionally a chronic congestion is suspected, which lasts for months, and is attended by symptoms of neurasthenia.

The *diagnosis of spinal congestion* is an uncertain one. When symptoms such as those described appear, and do not go on to more serious conditions, but gradually pass off, and an adequate cause can be found, the diagnosis can be made. If, however, serious symptoms of myelitis ensue, it must be admitted that the disease was myelitis from the outset, and not a simple hyperæmia. A long duration of symptoms of spinal congestion points rather to the existence of capillary hæmorrhages, attended by small foci of inflammatory degeneration, or to nutritive changes in the spinal cord.

The *prognosis* should always be reserved, in view of the uncertainty of diagnosis and the possibility of myelitis.

The *treatment* should consist of absolute rest in bed, in a prone position; the application of cool cloths, wet with an evaporating lotion, to the spine, or an ice-bag or the ether spray; saline purgatives; and full doses of ergot with small doses of belladonna.

M. Allen Starr.

SPINAL CORD DISEASES: HÆMORRHAGE IN THE CORD. Synonyms: Hæmatomyelia; spinal apoplexy.

Hæmorrhage in the spinal cord is very rare in comparison with hæmorrhage in the brain. When it occurs it is usually of small extent. This is not extraordinary when the size of the organ and the firmness of its connective-tissue sheath, and the low pressure in the spinal arteries, are considered. As a rule, the clot in the spinal cord is long and narrow. It destroys a considerable part of the cord at one segment, and extends into the segments above and below, injuring these to a less extent. The clot is usually found in the gray matter of the cord, most frequently in the anterior horns, then in the posterior horns, and most rarely in the white columns. Sometimes the surface of the cord is broken and the blood infiltrates the pia mater. As the patient rarely dies at once of hæmorrhage the clot is usually found in a state of decomposition, and the cord around it is infiltrated with blood-cells, pigment-granules, and hæmatin crystals. If the hæmorrhage is capillary—as sometimes occurs—it is detected by the presence of pigment and crystals among the degenerated spinal elements. Around the clot the spinal cord is usually found in a state of softening, which is red in recent cases, and white when the process has been a long one. At a post-mortem the question sometimes arises whether the condition found is a myelitis with secondary hæmorrhage, or a hæmorrhage with secondary myelitis. In the former case the microscopic examination shows a greater preponderance of granular corpuscles, a greater degree of degeneration in the nerve-cells, and a greater extent of connective-tissue growth. Secondary degenerations upward and downward from the segment destroyed, and secondary degenerations in the motor nerves from the segment affected to the muscles, are observed after spinal hæmorrhage as after myelitis. The meninges are rarely involved.

ETIOLOGY.—Spinal hæmorrhage is met with in males more frequently than in females, and in youth and middle age most often. The predisposing causes are chronic changes in the general arterial system, and inflammatory congestion or myelitis of the spinal cord. The exciting causes are the same as those of spinal congestion (*q.v.*), to which must be added the sudden exposure to a marked change of atmospheric pressure, to which workers in caissons and divers are exposed. The so-called caisson-disease is a congestion of the spinal cord (and brain ?) attended by minute hæmorrhages and secondary subacute myelitis.

SYMPTOMS.—Very rarely the symptoms of spinal congestion precede those of hæmorrhage. As a rule, the symptoms begin very suddenly, and the patient is seized in a moment with complete paraplegia and intense pain in the back at the level of the hæmorrhage. When premonitory symptoms have existed for a few days it is probable that the case is one of acute myelitis. A spinal apoplexy usually comes without any warning, after a sudden effort. The extent of the paralysis depends upon the level of the lesion. (See Local Lesions.) If in the lumbar or dorsal region, the lower half of the body only is involved; if in the cervical region, the arms are affected as well. The hæmorrhage is rarely so very limited as to affect one extremity only, but it is not infrequently the case that the symptoms are more marked on one side. The paralysis is total, no voluntary motion is possible, the limbs are relaxed and never rigid. The muscles do not atrophy or present any change in the electric reactions, excepting those which are supplied with nerves from the segment which is destroyed by the hæmorrhage. The condition of the reflex action depends upon the seat of the lesion, it is suspended at the level of the hæmorrhage,

and increased in the segments below it. The bladder and rectum are uniformly paralyzed, and various forms of incontinence of urine and fæces result, dependent upon the seat of the lesion. If this is high up in the cord, the viscus may empty itself occasionally, as the need arises, unconsciously to the patient and independent of his effort or control. If the lesion is low down (below the eleventh dorsal segment), there is usually retention of urine and fæces, or complete relaxation of the sphincters. Vasomotor paralysis accompanies the voluntary paralysis, and results in cyanosis and coldness of the paralyzed limbs, and predisposes the parts to the development of bed-sores. The latter appear, very soon after the hæmorrhage, on the prominent parts of the body which are subjected to pressure; voluntary movements to relieve such pressure, or reflex movements for the same purpose, being impossible on account of the lack of power and of sensation, for complete anæsthesia and analgesia exist in the paralyzed limbs from the outset. Pain in the back, which occurs at the time of hæmorrhage, does not usually persist. The danger in these cases is from the occurrence of bed-sores, or of cystitis, and consequent infection from these sources, with the development of septic fever. If the hæmorrhage involves the respiratory centres in the upper cervical region, sudden death takes place. This is rare.

The symptoms described are those of a severe hæmorrhage, sufficient to destroy one or more segments of the cord; if the clot is a small one, however, they may be more limited and less serious, partial anæsthesia and localized paralysis, with atrophy, being the result. This, however, is the exception. Capillary hæmorrhages give rise to wide-spread symptoms, which so closely resemble those of diffuse myelitis that differential diagnosis is impossible.

The *prognosis* is very bad in spinal apoplexy, for a destruction of the spinal elements cannot be recovered from. The patients either die suddenly, or die of complications, or linger on for months with all the symptoms of chronic myelitis. In the lighter cases they may recover sufficiently to get about, but some evidences of the hæmorrhage in the form of local paralysis or areas of anæsthesia, always remain.

The *diagnosis* is usually easy, the sudden onset of total paraplegia being characteristic. In meningeal hæmorrhage the paralysis is less marked than the spasms, and anæsthesia is rare. In poliomyelitis anterior there is marked constitutional disturbance, with fever, before the paralysis begins, and anæsthesia is not present. In acute central myelitis the onset is more gradual, the symptoms develop successively, they extend gradually to other parts, and fever is usual.

Treatment cannot reach the disease, and hence resolves itself into a care of the patient, and such measures as are used in the management of a case of chronic myelitis.

M. Allen Starr.

SPINAL CORD DISEASES: HYPERTROPHIC SPINAL PACHYMENINGITIS. Definition. — Hypertrophic spinal pachymeningitis is a chronic inflammation of the spinal dura mater, limited in longitudinal extent, and more generally affecting the region of the cervical enlargement, but occasionally found in the dorsal region or lumbar portion of the cord. This inflammation gives rise to thickening and hypertrophy of the dura mater, and secondarily implicates the arachnoid and pia mater, causing their adherence to the former membrane. The hypertrophied membranes, by pressure, produce a secondary transverse myelitis and atrophy of the nerve-roots arising from the affected region.

The cervical form of this affection, though mentioned by others previously, has been thoroughly studied and described by Charcot and his pupil Jeoffroy, from whom the greater part of our information is obtained.

Pathological Anatomy.—The primary and chief lesions of pachymeningitis spinalis hypertrophica are found in the spinal meninges, and particularly in the dura mater. On opening the spinal canal the marrow at the affected part is found to consist of a large fusiform tumor, filling the whole canal, and adherent or not to the vertebral ligaments. Upon section this tumor is found to be composed mostly of the hypertrophied dura mater, to which the other membranes, whether affected or not, are adherent, inclosing and making pressure on the spinal cord and nerve-roots. This tumor consists of a hard, fibrous, and dense tissue, arranged in concentric layers, and has for its origin an inflammation of the internal surface of the dura mater with proliferation of the connective tissue.

As secondary lesions, we find the spinal cord compressed by this hypertrophied tissue as in a ring, and showing signs of transverse myelitis with ascending degeneration of the posterior columns. This transverse myelitis is caused by the compression of the cord, but it is believed in some instances to be due to extension of the inflammation from the meninges. The nerve-roots arising from the affected region are also compressed, pale, and atrophied, but the nerves beyond have been

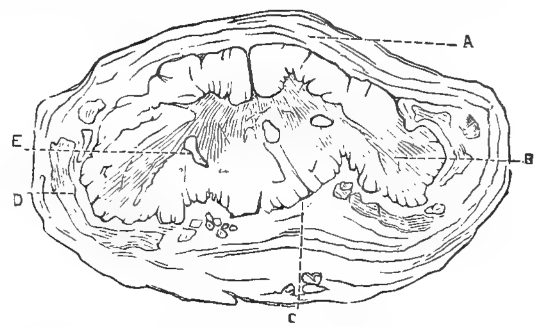

Fig. 3646.—Hypertrophic Cervical Pachymeningitis. A, Hypertrophied dura mater; B, nerve-roots passing through the thickened meninges; C, pia mater adherent to dura mater; D, lesions of chronic myelitis; E, section of two newly formed canals in the gray substance.

found normal. The muscles supplied by the affected nerves show signs of atrophic degeneration.

Pulmonary tuberculosis or cystitis, with bed-sores, is generally found as the cause of death.

Etiology.—This is a disease of adult life. No predisposing cause is known, though syphilis and alcoholism are supposed to act as such, for a number of the observed cases were seen in inebriates or syphilitic persons.

Exposure to cold and dampness is the only known exciting cause, though in some instances the inflammation may have extended from a previous perimeningitis, and in a case observed by me, and here related, a fall on the back of the neck seems to have acted as the exciting cause of the pachymeningitis.

Symptoms and Clinical History.—Hypertrophic spinal pachymeningitis may be divided into two distinct stages or periods: The irritative or meningitic period, and the paralytic and atrophic, or myelitic, period.

In this article we shall describe the cervical variety of the disease, which is the most common, and the only one which has been thoroughly observed.

Irritative Period.—This affection, which is generally insidious, first shows itself in one of two forms, the central and the peripheral. The predominating symptoms in the central variety are pain and stiffness in the back of the neck, radiating to the occiput and head. The pain, at first mild in character and resembling that of wry-neck, presents distinct periods of exacerbation, and is generally worse at night; in a short time it becomes constant, and is always aggravated by motion of the neck, rarely by pressure upon the spinous processes. Along the limbs dull pains of a rheumatic character are then experienced, and in the joints sharper shooting pains, at times increased by pressure. The joints remain normal as regards swelling and redness. In the fingers and hands there are numbness, formication, and a greater or less diminution of tactile sensibility. These peripheral pains are generally more marked on one side than on the other: they are the first to show themselves in the peripheral form of the disease.

Spinal Cord.

Later on, the pains extend along the spine to the lumbar region and to the lower extremities, occasionally more on one side than on the other; they increase to such a degree that the patient is forced to give up his occupation, and at times to betake himself to bed. Nausea and vomiting are frequent at this stage, and seem to further weaken the patient.

This period lasts from two or three to five or six months, when, in some cases, there is a period of comparative improvement, and in others the second period is ushered in.

Second or Paralytic Period.—In this period, also known as the chronic period, paralysis usually appears in one of the upper extremities, as a rule in the one in which the pains were first or more acutely felt, but it soon extends to the other extremity. This paralysis, which progresses with more or less rapidity, is always accompanied by atrophy and diminution of electrical excitability. The atrophy, in the majority of instances, is limited to the pronators and flexors of the hands, and all the muscles supplied by the ulnar and median nerve, or is more marked in them than in the supinators, extensors, and other muscles supplied by the musculo-spiral nerve. This may be due to the fact that the lower portion of the cervical enlargement, from which the ulnar and median nerves arise, is more often implicated than the upper portion of the enlargement, from which arises the musculo-spiral nerve. In the non-atrophied muscles contracture sets in early, giving rise to peculiar deformities, the more common of which is the claw, or preacher's hand, in which the hand is extended at the wrist, the third phalanges extended and the two first remaining flexed. This deformity, though not found in this affection only, is, however, one of its marked characteristics.

The paralysis next invades the lower extremities, but in these atrophy seldom or never occurs; at times, however, the muscles of the lower extremities, as well as those of the trunk, tongue, and lips, all become atrophied. Paralysis of the muscles of respiration, bringing the case to a speedy fatal termination, rarely occurs.

The sensory symptoms have not been so well studied, and do not seem to be as constant; there is first paræsthesia, followed later by anæsthesia or hyperæsthesia, or there is anæsthesia of one extremity and hyperæsthesia of the other.

Trophic changes have also been observed, such as itching, dryness, and desquamation of the skin over the affected regions, or the development of a vesicular or bulbous eruption over the affected hands and arms. Acute eschars form at times on the buttocks, over the sacrum, on the heels, or in the mucous membrane of the bladder, giving rise to a bad form of cystitis. The bladder and rectum are paralyzed late in the course of the affection.

Occasionally convulsive motions of the limbs, amounting at times to spinal epilepsy, have been observed. The reflexes are exaggerated in some cases, in others they are not affected.

When the dorsal region is affected, we have the atrophy, paralysis, and trophic changes affecting the trunk; early paralysis of the lower extremity, and complete immobility of the upper extremities.

When the lumbar region is alone affected, the symptoms are limited to the parts supplied from this portion of the cord.

The following case illustrates the course of pachymeningitis hypertrophica spinalis ending in recovery:

E. F——, white, male, aged forty-five, single, laborer, intemperate in habits, gives no family history of disease, but had syphilis twenty years ago. He was admitted into the ward for nervous diseases of Charity Hospital, on May 2, 1885, with the following history: One year before admission, the patient was thrown from a horse and fell on the back of his head and neck; he was able to pick himself up after the accident, and, though he suffered greatly with pain in the neck and head, returned home on foot, a distance of several miles; he was confined to his room for several weeks, suffering from shooting intermittent pains in the back of the neck and head; the neck was very stiff, and the least motion or touch on the parts gave rise to excruciating pains. Accompanying this, and developing shortly after, were numb feelings and occasional shooting pains extending down the arms and hands, especially on the left side, the elbow and wrist were very tender and painful, making it almost impossible for him to raise his arm. About twelve weeks after the injury the pains in the neck, head, and arm had greatly increased, and he could make little or no use of his upper extremities, which were stiff and useless. About this time the muscles of the hand and forearm began to waste, and his hand was drawn back over the arm at the wrist, the fingers being extended; he began also to feel weak and stiff in the legs, and to be troubled with retention of urine and costiveness; the pains in the legs, however, were never so great that he could not move about, though he was incapacitated for work.

Upon admission his general condition was found to be good; there were no general symptoms; his arms and hands were almost completely paralyzed, the left more so than the right; there was atrophy of the pronators and flexors of the hands and fingers, and of the biceps; the extensors of the upper extremities and supinators were contracted. The deltoids were normal. He had the typical claw hands, and had to be fed, being unable to bring the food to his mouth. The lower extremities were well developed, but he complained of weakness causing tremor and stiffness; his gait, when walking, resembled that of a patient with spastic paralysis. The bladder was somewhat affected, the patient having to empty it almost hourly; the bowels were costive, only acting when stimulated. The muscles of the neck and upper part of back were stiffened. Sensation, both general and tactile, was greatly diminished in the upper extremities, but the neuralgic pains in the head, neck, and arm had almost completely disappeared, coming on only at rare intervals; sensation in the lower extremities was a little below normal. The patellar tendon reflex was exaggerated, and there was marked ankle clonus in both legs. The faradic and galvanic irritability was present, but greatly diminished in the upper extremities, though almost normal in the lower extremities.

The patient was put on tonic treatment, and a mixture of the bromide and iodide of potassium, grs. xv. of the former and grs. x. of the latter, given three times daily; dry friction was made over the extremities, and the continuous current was applied to the back and arm, the faradic to the lower extremities. At the end of six months there was marked improvement, the patient felt stronger and could walk better, though the legs still felt stiff. He could also flex his fingers almost to the palm of his hand, and bring the right hand to within two inches of his mouth, and thus feed himself; the pain in the back of the neck and limbs had disappeared, and, subjectively, sensation in the upper extremities was very much improved. Slight response in the atrophic muscles could be obtained with a twenty-four-cell bichromate of potash galvanic battery; the hands and forearms looked a little fuller. The control over the bladder was nearly normal, the viscus being emptied only three or four times during the night, and about twice as often in the daytime; the bowels acted without assistance. His condition continued to improve until December, 1886, when he left for Cincinnati, having obtained some occupation in that place as keeper in a warehouse. When he left the hospital he could be on his feet all day; sensation was quite normal, and, aside from a slight stiffness in the leg, he felt no untoward symptom in walking. He could bring his hands to his mouth and shut the fingers, though he could not hold a weight.

This case, on account of the rapid improvement and amelioration of the worst symptoms, should, in our estimation, be classed as a case of cure.

Course and Termination.—The course of the disease is generally progressive, but the affection may last for a number of years. The termination is generally fatal, the more rapid cases terminating fatally in about five years, the slower ones lasting from fifteen to twenty years. Occasionally cases, like the one just reported, re-

cover. Charcot has reported a case, much more advanced than ours, in which the same happy termination took place.

DIAGNOSIS.—This affection may in its initial stage be confounded with torticollis. The fact that the whole neck is implicated, instead of one side, and the presence of radiating pains in the upper extremities, will, however, suffice for a diagnosis.

Hysteria is to be distinguished from the initial stage of the peripheral form by the other symptoms pointing to that hybrid affection.

Progressive muscular atrophy is to be differentiated by the absence of painful symptoms, the more limited atrophies, and the difference in its seat, and by the absence of the claw-hand.

Myelitis can be distinguished only by the history of the case.

Pott's disease of the vertebræ can usually be diagnosticated by its history.

PROGNOSIS.—The prognosis of pachymeningitis, as a rule, is unfavorable; but, from what has been said above, a cure may be hoped for in a few cases, even after the symptoms denoting the secondary involvement of the nerve-roots and cord have appeared. In a number of cases, however, when the symptoms are meningitic only, much can be hoped for with appropriate treatment.

TREATMENT.—In the first period of the affection, in robust and plethoric patients, antiphlogistic measures may be resorted to; but with the majority of cases the treatment must be symptomatic and carried out on the same general principles as that for other forms of meningitis.

Sedatives, such as opium, but preferably chloral hydrate and bromide of potassium, to relieve pain; belladonna and ergot, to limit the extent of the inflammatory processes; iodine and the iodides, to favor the reabsorption of the exudate material, and to diminish connective-tissue proliferation, are called for.

The use of the actual cautery to the spinal column, recommended by Jeoffroy and Charcot; electricity, especially the galvanic current, to the spine, and hydrotherapy are all at times indicated.

In the second stage, the continued use of iodide of potassium in large doses; of tonics, to keep up the patient's strength; counter-irritants, especially the actual cautery, to the spine; electricity, both galvanic and faradic; massage, etc., are of service.

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P. E. Archinard.

SPINAL CORD DISEASES: INJURIES AND WOUNDS. Injuries of the spinal cord and membranes were studied and described by Sir Astley Cooper and other surgeons of the last century with considerable minuteness and care. Microscopic study and the investigations of neurologists have so supplemented clinical study that the pathology of diseases of the cord has been almost entirely rewritten within a short term of years, and these investigations are not to be left out of account in considering the surgical diseases of the nervous system. Part, at least, of the changes resulting from injuries to the cord and membranes are identical with those found in disease. An intelligent understanding of their nature can, therefore, be obtained only through acquaintance with recent important investigations on the functional and organic diseases of the spinal cord. We cannot here enter into the pathological and normal anatomy as studied in disease and in experiments upon animals. This subject has been fully discussed in a preceding article.

It is sufficient to call attention to the importance of these investigations, a knowledge of which is at the foundation of a proper understanding of the effect of injuries upon this part of the nervous system. Not only are the local structural changes often the same in disease and in the results of traumatism, but secondary effects appearing in remote organs are frequently identical, whatever the primary lesion. It is evident that much of the discussion of spinal injuries in surgical treatises is based upon clinical and not upon pathological data. It is also true that writers of eminence have treated this subject, which is often a medico-legal one, almost in a controversial spirit, drawing opposite conclusions in some instances from the same clinical evidence.

Erichsen has collated numerous cases from the published works of Cooper, Bell, Abercrombie, Brodie, and others, which he has added to his own in illustrating certain ideas on spinal "concussion." Page, on the other hand, has drawn largely from the same sources, and even from Erichsen's own cases, to support views quite opposite. Neither writer utilizes to the full the best results of modern investigation on the pathology of the cord. We are therefore left with the impression that much of this discussion is but threshing old straw, so far as scientific interest is concerned, however much importance may attach to it in the eyes of lawyers and claim-agents. It is well, nevertheless, for all medical men who are subject to calls for expert testimony, and especially in railway practice, to be conversant with such works as that of Page.

CAUSES.—The spinal cord is exceedingly well guarded from all external violence. Axially situated with reference to all bodily movements, protected by its semi-rigid bony and ligamentous canal and by thick cushions of muscles, there would seem to be little liability of its receiving mechanical injury except in destructive accidents to the vertebræ. On the other hand, the fragile and soft texture of the gray matter of the cord makes it more vulnerable than most tissues. Even the white fibrous columns, which surround and inclose the gray matter, are comparatively frail and intolerant of interference, so that slight causes, when persistent, may set up serious alterations of structure. It is not to be inferred that complete recovery cannot take place after considerable violence has been done to the cord-substance as well as the membranes, provided the source of irritation or compression has been completely removed. This *must be* true of slight lacerations, since it has been observed clinically in actual wounds of the cord-substance.

Meryon describes a case of incised wound in a lad, fifteen years of age, in which the spinal canal was penetrated by a knife between the tenth and eleventh dorsal vertebræ, and the cord was partially divided, so that there was escape of spinal fluid and paralysis of parts of the body below. The left leg and thigh were completely paralyzed, and it was inferred—without doubt correctly—that the cord had been partially severed. The patient, notwithstanding, recovered entirely in two months. Many such cases of complete or partial recovery have been recorded, which show that reparation is possible in the nerve-structure under favorable circumstances. It cannot be asserted that this is usual in penetrating wounds; but in simple injuries, such as laceration of membranes, contusion, or "concussion" of the cord, and small circumscribed hæmorrhages, even when accompanied by paraplegia, perfect recovery may often be expected.

Blows upon the spinal column, without producing any fracture or displacement of the vertebræ, may cause symptoms ranging from slight neuralgia to complete paraplegia. This is the simplest type of injury to the spinal cord or membranes, and is analogous to similar injuries to the brain from blows upon the skull. It cannot be said that this is very common in the typical form.

In "Guy's Hospital Reports" for 1856 is described the case of a boy who was struck in the back with the fist, and shortly afterward developed pain in the extremities, difficult urination, spasm of the muscles, and other signs of spinal irritation. The patient soon died, and the autopsy showed the spinal canal nearly filled with pus. It is so unusual for traumatic arachnitis to take a suppura-

tive form, when no external wound and consequent sepsis has occurred, that some doubt may be entertained in this case as to whether the blow was the real cause of the disease.

Genert describes the case of a woman, forty years of age, who received a blow upon the back, which was followed by pain and loss of voluntary motion, beginning in the right foot, and gradually extending over the body, with spasmodic contractions and ultimate death. The autopsy showed the posterior columns softened and inflamed in the lumbar enlargement.

By far the greater number of injuries to the spinal cord are the result of *indirect violence.*

Falls which produce no injury to the bones either of the extremities or of the spinal column are often followed by symptoms indicating functional or structural derangement of the spinal cord. Many observers have noticed the fact that the spine usually escapes injury when the extremities suffer, as in fractures and dislocations.

It may be that some cases of spinal irritation pass unobserved on account of the graver trouble which is present. The enforced rest involved in the treatment also has a most favorable influence upon the speedy recovery of such cases.

Erichsen inclines to the theory that the traumatism in one part of the body breaks the force of the blow received, and thus diminishes the violence of its effect upon the spine. He adduces the statement of watchmakers that, when a watch falls to the ground, "if the glass be broken, the works are rarely damaged ; if the glass escape unbroken, the jar of the fall will usually be found to have stopped the movement." As an illustration rather than an exact analogy, this serves to explain how the sacrifice of one member may save the integrity of another.

A blind man was admitted to my department, in Mercy Hospital, in 1880, who had walked out of a third-story window and struck upon his feet, fracturing both his thighs. It is easy to believe that, had the femurs not broken under the tremendous impact of the body, the contents of the spinal canal might have suffered from the shock.

Extreme bending or *twisting* of the spinal column is responsible for a large number of cases of irritation of the cord.

Slight injuries to the vertebræ, to the intervertebral disks, or to the ligaments may, just as in the case of other articulations, extend somewhat to surrounding parts, and give rise to localized meningitis and thickening.

Page has pointed out that irritation of the posterior common ligament cannot occur without risk of injury to the spinal membranes, not so much by their being implicated at the time of injury as by extension of the inflammation to adjacent parts. The ligamenta subflava are also, as he observes, in such immediate relation with the meningo-rachidian veins that laceration of their substance will produce rupture of the veins and extravasation of blood into the spinal canal, a state of affairs which may cause immediate impairment of function, followed by inflammation and degeneration of the cord.

Railway accidents are the cause of a large number of alleged injuries to the spinal cord. This is universally known outside the profession, as well as in it, and its importance lies chiefly in the number of suits for damages against railway companies which arise from it. Erichsen declares that injuries received in railway accidents are not essentially different from those occurring elsewhere. That they are more common on railways is probably true ; but it is also a fact that such injuries are sometimes much exaggerated by patients from mercenary motives.

Page, whose treatise is written with the intent to minimize the importance of this class of cases, nevertheless gives detailed histories of 250 cases occurring in his own private and hospital practice, and intimates that he could furnish records of at least 500 from the same source. Many of the cases cited are fraudulent. Yet the fact seems evident that they are very numerous in railway surgery.

Symptoms.—The signs of injury to the cord are to be referred chiefly to perverted or impaired innervation of the parts below the lesion.

Disorders of sensation are among the earliest symptoms.

Pain, which is for the most part absent locally, is often felt in the form of neuralgias of the parts supplied by the spinal nerves below the point of injury. These pains are usually radiating and intermittent, and are often aggravated by movements. Usually they precede paralysis where the latter occurs.

Local tenderness is a symptom so inconstant as to be of little importance. When present, it may point to injury of the bones or spinal muscles.

Anæsthesia and *analgesia* are common symptoms of spinal injuries involving either the sensory nerve-roots or the anterior columns. Complete loss of sensation may come on when there is paraplegia.

Hyperæsthesia is also a prominent symptom in a certain number of cases, particularly in the earlier stages. Even when there is total paralysis of motion there may be exalted sensibility of the skin. A light touch upon the legs or genital organs may produce the sensation of severe cutting or burning.

Disordered spinal reflexes are closely allied to sensory disturbances, and perhaps to some extent dependent upon them. Exalted action may coexist with, and depend upon, increased sensibility. The so-called "spastic paralysis" is a form of paraplegia in which the limbs are suddenly and violently flexed or extended when touched, quite independently of the patient's control. The jerking may be so violent as to cause pain and visibly jar the bed. It has been likened to the snapping of a pocket-knife. The paraplegia of disease—as of Pott's disease—is sometimes of this form.

Continuous or *tonic muscular spasm* is a constant and early symptom of the milder forms of spinal irritation, especially those affecting the anterior columns. This is probably due to reflex irritation.

Priapism, which is also common in injuries of the spine, may possibly be due to reflex action, or, as Agnew suggests, to paralysis of the sympathetic fibres within the cord. Bramwell attributes this symptom to irritation of the excitor fibres which pass down from the brain. Priapism is said by some authors to result only from injuries high up in the cord ; but Lidell quotes a case wherein it occurred from injury at the level of the tenth dorsal vertebra. Surgeon Tripler, U. S. A., describes a case from an injury at the junction of the dorsal and lumbar vertebræ.

Impairment of reflexes is an important symptom of another class of cases which usually are accompanied by more or less analgesia and anæsthesia. Knee-jerk and ankle-clonus are very frequently entirely wanting, but the cremasteric and epigastric reflexes are also abolished. Such cases are apt to show more or less inco-ordination of muscular action, and consequent impairment of gait and movement.

Motor derangements are present in most cases of spinal irritation. Inability to empty the bladder and rectum are common and early signs, with or without paralysis of the extremities.

Partial or complete *paraplegia* is the most characteristic sign of injury to the cord, whether from wounds, fractures of the vertebræ, or simple concussion.

The loss of voluntary motion may be of all degrees, and with or without muscular rigidity or lack of co-ordination.

Trophic disorders are seldom wanting in the paralyzed parts. Muscular atrophy is usually seen after a certain time has passed. Among trophic disorders may also be noted the "neuropathic eschars" (Brown-Séquard) which form upon the sacral region in cases of paraplegia. These sometimes appear so early after injuries of the spine that they can hardly be due to pressure alone, like ordinary bed-sores. They may also appear in other localities. Conant describes several cases in which they were seen upon the inner aspect of the thighs. Stephen Smith reports a case of injury to the spinal cord, followed by

neuropathic sphacelus upon the heel and ball of the great toe.

Another form of trophic disorder is the remarkable affection of the joints first observed in locomotor ataxia by Charcot, and called by him "arthropathy." The limbs become suddenly swollen to an immense size, and are almost as suddenly reduced, after which the joints and bursæ are found distended with fluid. Remak and Patruban observed similar joint-affections in the disease called progressive muscular atrophy. Sir William Gull described a case of "concussion of the spine" in which there was paraplegia accompanied by great enlargement and redness of the wrists and ankles, lasting four months.

Excessive sweating and increase or diminution of temperature over limited areas of the skin are probably the results of vaso-motor derangements through the sympathetic fibres within the spinal cord.

Cerebral and functional derangements largely predominate over the symptoms of spinal irritation in a certain class of cases, particularly those resulting from railway accidents. While there may be a slight basis of spinal trouble, the chief symptoms in many of these cases are those of nervous prostration from fright and worry; and the trouble, so far as it can be located at all, is in the brain, and not in the spinal cord. Many of these cases need the attention, not of a surgeon, but of a neurologist.

A misleading impression has gotten abroad, not without some authority, that these symptoms, clearly of the mind, or at least cerebral, are the ultimate results of spinal concussion. There is nothing in the pathology of the cord, as now known, that will support this view, however. It is more scientific to separate carefully those symptoms which are spinal from those which are cerebral, and much controversy can in the future be avoided by keeping this distinction in view. As to "railway spine," it has very justly been said that "railway brain" would be a more appropriate designation. Most of the symptoms alleged in these cases are not those of spinal origin. It is "safer and wiser to separate and differentiate those symptoms which are cerebral or psychical from those which can only find an explanation in some actual lesion of the spinal cord or of the nerves which are given off from it."

Headache, loss of memory, sleeplessness, melancholia, and "lack of business aptitude" are the symptoms most often spoken of in this relation. Impairment of vision does, however, occur in slight injuries of the cord. This is probably due to simple atrophy of the optic nerve and hyperæmia of the disk (Albutt, Wharton Jones).

Temporary impotence is not rarely an accompaniment of injuries of this class. Irregular attacks of nausea from functional derangement are also quite common.

The PATHOLOGY of injuries of the cord is to be understood only by keeping in mind the various columns of degeneration which have been mapped out by pathological study. An understanding of the various functional disorders which may simulate organic diseases of the cord, and of the curious and interesting subject of spinal reflexes, is also a requisite for a thorough comprehension of the effects of injuries. These matters will be found adequately discussed elsewhere in this volume, and still more fully in the works of Bramwell, Gower, and other writers.

The pathology of injuries is not wholly dissimilar from that of diseases of the spinal cord. In at least one affection—tabes dorsalis or locomotor ataxy—there is evidence that idiopathic and traumatic cases may be identical in kind. Leyden maintained this view in 1863, and was corroborated by Topinard (1866). Petit (1879) also tries to show that ataxy may be of traumatic origin. Page, while not absolutely denying the possibility of this being true, holds it to be improbable, since it is a disease of definite tracts, and it is not likely that these alone would be injured in case of an accident. Gower thinks this might result from the whole cord being at first involved, and all parts except the posterior columns recovering, leaving the latter degenerated. It is not to be forgotten that there may be syphilis back of such cases.

In place of the term "concussion of the spine," it will be better, so far as possible, to use more definite terms. This we can now do with considerable certainty when speaking of many of the morbid conditions which result from injury of the cord and membranes.

Intraspinal hæmorrhage, following slight lacerations of the ligaments or nerve-substance, is the starting-point of many slight impairments of function as well as many grave ones.

The close relation of the meningo-rachidian veins to the fibres of the ligamenta subflava makes it probable that they would be torn when the latter are ruptured. Hæmorrhage may be slight in quantity, so as to form mere ecchymoses upon the surface of the cord or membranes, or it may fill the spinal canal and produce fatal compression. The signs of compression can hardly appear as quickly as in the case of a fracture, and in many cases some hours or days elapse before serious impairment of function is noticed. Lidell believes the diagnostic sign of hæmorrhage to be the fact that the symptoms begin at a point low down and gradually ascend as the level of the blood rises in the spinal canal.

Brown-Séquard asserts that hæmorrhage within the substance of the cord is distinguished from accumulations around it by the absence of convulsions, and the gradually diminished sensation in parts below. Hæmorrhage around the cord compresses the roots of the spinal nerves, giving rise to convulsions as well as paralysis of motion.

Traumatic meningitis of a subacute form is a common result of slight injuries of the spine. Some thickening of the membranes occurs when the irritation is persistent, and, doubtless, compression of the cord occurs in this way without actual inflammation of its substance, or myelitis. Serous or purulent exudation into the arachnoid, and congestion of the pia mater, with occasional ulceration and perforation of the membranes, are the principal features of this affection.

Traumatic myelitis and meningo-myelitis of traumatic origin may be limited to the region where the injury has been received, or may extend so as to involve adjacent columns. Extension upward or downward to any great distance is not usual. The inflammation is of a subacute or chronic type, and quite commonly ends in complete resolution, with disappearance of the paralysis or other symptoms. A few cases end fatally from paraplegia and final exhaustion. Gower saw a case of slow paralysis following a railway injury which ended fatally, and in which the autopsy showed the gray matter of the cord studded with numerous minute foci of chronic inflammation.

Pure concussion, if it exist as a pathological state, may be defined as a "stunned" condition of the cord, which is assumed to have undergone some form of molecular derangement too slight to reveal itself in the gross appearances, yet sufficient to cause functional derangement. There are well-attested cases in which paraplegia and death have occurred from supposed injury to the spinal cord, in which, on post-mortem examination, no injury to the nervous substance could be detected. Yet, if we remember the liability to overlook cerebral injuries, and even clots in the substance of the cord itself, we cannot always assert with positiveness that some important lesion may not have escaped notice. It is only within recent years, and in a very few hospitals, that post-mortem examinations have been conducted exhaustively. Lidell describes a case of fatal injury to the cord, in which the autopsy at first showed apparently no lesion in the cord until, upon careful section, a globular clot was found at one point, in its very centre, which had so compressed its substance as to cause death.

TREATMENT.—The treatment of injuries of the cord and membranes calls for rest, not merely physical but mental, and complete immunity from care and worry. The reason for this is that all parts of the nervous system suffer in these cases, and all parts respond unfavorably when any cause of nervous excitation exists. There are many cases in which the spinal symptoms alone are of importance, and others in which mental and psychical disturbances seem to be the main features, but all alike

receive benefit from a somewhat prolonged rest in bed. The mechanical effect alone is of course considerable, but the functional rest which it gives to the reflex centres of the spinal cord, by the mere cessation of bodily movements, is equally important.

Mechanical appliances for the fixation of the spinal column are more useful in irritations of the bones and muscles than of the cord itself. Yet it is often the case that all these structures are more or less strained and injured, so that what helps the recovery of one helps all. For sprains of the back, with or without definite injury of the cord, casts and splints are decidedly useful. By immobilizing the spinal column they aid materially in securing perfect rest to the injured cord and membranes, and so hasten their recovery.

Sedatives should be used cautiously, and not too continuously, where there is reason to suspect that a general condition of depression already exists. Bromides in moderation are allowable, particularly to induce sleep, the loss of which is of itself extremely depressing; but Page warns us against the prolonged exhibition of the bromides, on account of their depressing effects.

WOUNDS OF THE SPINAL CORD.—The results of wounds of the cord and membranes depend largely upon the failure or success of closure by first intention, the absence or presence of suppuration, or, in other words, of septic infection.

Of the more favorable type a case has already been mentioned.

Hurd (1845) described an instructive case of a man who fell upon his back in jumping from a wagon.

"In attempting to rise he found his lower extremities paralyzed; calling for help, he stated that a chisel, which he had carried in his coat-tail pocket, was sticking in his back; to extract it required the united efforts of several men. It measured five inches in length to the shoulders, was seven-eighths of an inch in width, and one-eighth of an inch in thickness at the cutting end. It had entered to the shoulders. During the extraction the patient suffered very little, but said he saw, apparently, vivid flashes of light, which were followed by total darkness. The wound was opposite the lower dorsal vertebræ. There was total loss of cutaneous sensibility below the wound, with the total loss of voluntary motion, and paralysis of the bladder and rectum.

"The patient was prostrated for forty hours, and then reaction was followed by fever for several days. The wound healed rapidly. The urine was withdrawn by the catheter for eight days. Cutaneous sensibility returned on the fifth day, and imperfect use of the limbs about the fifteenth. After five years he still walked with crutches."

This case, which is not entirely exceptional, is an illustration of the favorable results which follow primary union and the avoidance of suppuration. While there is a lack of absolute proof that the cord was even partially severed, there is a strong probability, almost amounting to a certainty, that this was the case.

The results of laying open the spinal canal, where septic infection occurs, are in startling contrast to the above.

Acute purulent inflammation of the cord and membranes, well deserving the name *foudroyant* which has been applied to it, soon terminates the life of the patient.

Chills, followed by pyrexia and general hyperæsthesia, with paralysis below the point of injury, usher in the attack. Tetanic spasms of the muscles occur, as in cases of cerebro-spinal meningitis. Delirium, coma, and death very shortly follow. Post-mortem examination reveals extensive inflammation of the meninges over the whole cord and base of the brain.

Gunshot wounds of the spinal cord are not essentially different from wounds received in other ways. They are seldom uncomplicated by wounds or fractures of the vertebræ.

The treatment of wounds of the cord should be conservative, so far as circumstances allow; *i.e.*, the wound should be as little explored and disturbed as possible, save for disinfection in certain cases.

Primary closure should be sought by every means possible. It is not to be forgotten that bullet wounds are often favorably inclined toward healing even when the bullet is not extracted, and that, rather than disturb the newly formed coagula which seal such a wound, it is safer, in some locations, to leave the bullet. It is generally safe to do this, since, from their form and unirritating properties, leaden bullets are now known to be among the least objectionable of foreign bodies. The general principles of the treatment of wounds of the cord are the same as those to be followed in cases of simple injury. *Edmund Andrews.*

SPINAL CORD DISEASES: LATERAL SCLEROSIS.

(*a*) PRIMARY LATERAL SCLEROSIS.—Synonyms: Spastic spinal paralysis; tabes dorsal spasmodique.

Definition.—The disease is characterized by a gradually progressing paralysis, which begins in the lower extremities, is accompanied by greatly exaggerated tendon reflexes, muscular rigidity and contractures, and is not attended by sensory, trophic, or visceral symptoms. The anatomical basis is supposed to be a primary sclerosis of the antero-lateral columns.

Etiology.—We know very little of the causes of the disease. It occurs chiefly in adults, more frequently in men than in women. Exposure, excessive venery, etc., have been assigned as causes in individual cases. Some cases occurring near Rome, several of which were in one family, seemed to be due to the effects of a leguminous article of diet, *lathyrus cicera*.

Symptoms.—The disease begins with weakness in one or both lower extremities. There is an undue sense of fatigue on exertion, and an objective examination shows a slight paresis. There is at the same time some difficulty in walking, this being, at first, most noticeable on rising in the morning. As the paresis increases, motor irritation symptoms are soon manifested. These are at first slight clonic or tonic spasms of the affected muscles. They are most likely to occur when the patient is fatigued, are easily evoked by active or passive movements of the limbs, but often come on in the middle of the night. The tendency to muscular spasm—brought on by either a voluntary or a passive movement, or in a reflex way—increases to such an extent that complete muscular rigidity and contractures of the limbs occur. This condition antagonizes every action of the patient, makes his voluntary efforts altogether futile, and, therefore, causes the paralysis to appear more complete than it really is. The rigidity can usually be overcome, in early periods, by slow persistent pressure, but when it becomes excessive it resists powerful efforts. The usual position of the rigidly contracted limbs is that of extension at the knees, the feet in the equino-varus position, and the thighs firmly pressing against one another. Their immobility is often interrupted by clonic spasms, and occasionally the limb is drawn for a short time into another position.

A striking, and usually an early, symptom is the exaggeration of the deep reflexes. The patellar tendon reflex is greatly exaggerated; muscular contractions can be elicited by striking any of the tendons—the inner or outer hamstrings, etc., where tendon reflexes cannot be elicited, as a rule, in health—and even tapping over the periosteum will produce like manifestations. But the most striking of these phenomena is the ankle clonus, rapid and rhythmical clonic contractions taking place when the foot is sharply flexed, and continuing as long as the foot is held in a flexed position. When the reflexes are much exaggerated the clonic contractions, on evoking the ankle clonus, may not be limited to the ankle, but may extend to all the muscles of the extremity. The ankle clonus also becomes a disturbing element in walking, as every time the body rests on the toes in progressing forward there is a tendency to its production.

The gait is very characteristic. As the legs are weak and stiff the feet cannot be freely lifted, and, when moving forward, sweep the floor, making an almost characteristic scraping sound. At the same time, in order that the foot can be brought forward, it makes a wide out-

ward sweep. The gait is sometimes further impaired by clonic spasms of the muscles—those representing the foot clonus, as just described—which may cause a temporary halt in walking, or may make that act altogether impossible. Walking is more difficult on an up or down grade, and on an uneven surface, than on the level and on an even surface. It usually becomes easier after the patient has walked for a while.

The disease slowly extends upward, involving the muscles of the abdomen, back, and upper extremities. The latter are usually affected to a less degree than the lower extremities, though exaggerated reflexes and muscular tension are associated with the paresis. They may even be rigidly contracted. In that case the position is usually one of slight flexion and pronation of the forearm, and strong flexion of the wrists and fingers, the arm being pressed firmly against the body.

In typical cases there are no further symptoms on the part of the nervous system. The sensibility is intact, the functions of the bladder and rectum normal, there are no trophic changes in muscles or skin, and no special changes in the electrical reactions.

The symptoms do not always appear in the order just given. In rare instances the disease attacks the upper extremities before the lower, or occurs first in hemiplegic form, the arm being affected on the same side as the leg before the second lower extremity is involved. The progress of the disease is usually very slow. Though the patient be altogether bedridden, and without power of motion, the general health need not suffer. Unless there be some complication he may live to old age.

Morbid Anatomy and Physiology.—Symptoms like those of spastic paralysis had been observed with various diseases, but Erb was the first to describe this as a separate and distinct disease, whose basis he believed to be a primary sclerosis of the antero-lateral columns, especially the pyramidal tracts. His views have been pretty generally accepted, but yet, it must be acknowledged, there has not been much positive evidence to substantiate them. In a number of post-mortem examinations, where this disease was diagnosed during life, lesions in the brain, tumors in the medulla oblongata, diffused scleroses, etc., were found. In only a few instances did the disease appear to be a primary sclerosis of the lateral columns. But it is probable, whether or not a primary disease be usually found, that the pathological changes in the lateral columns produce the symptoms of this disease, for when spastic symptoms are found with multiple sclerosis, diffuse myelitis, etc., the lateral columns are found to be affected.

The paresis or paralysis is explained by the destruction of nerve-fibres in the pyramidal tracts, the tracts conveying voluntary motor impulses. The motor irritation symptoms cannot be so satisfactorily explained. Charcot believes them to be due to dynamic changes in the large ganglion cells, these being placed in a state of irritation by the degenerated nerve-fibres of the pyramidal tracts, which terminate in them. Hughlings Jackson supposes that the influence of inhibiting centres in the brain is removed by the destruction of the pyramidal tracts, and thence arise the excessive motor manifestations.

Diagnosis.—The symptoms of spastic paralysis may appear with multiple sclerosis, transverse or diffuse myelitis, or brain lesions. In these cases we must look for the further symptoms of these various diseases, indications of involvement of the gray matter and posterior columns in transverse myelitis, optic atrophy, nystagmus, intention tremor in multiple sclerosis, etc. In cases of multiple sclerosis there may for a long time be no other symptoms than those of spastic paralysis, in which case a correct diagnosis would be impossible.

Quite a number of cases have been reported in which there was apparently primary sclerosis in various strands of the spinal cord, termed combined systematic disease. In these, symptoms like those of lateral sclerosis were often found, but there were usually additional manifestations, symptoms on the part of the bladder, etc.

Yet it is quite probable that, in case of primary disease in the lateral columns, there might, with the lapse of time, be extension by contiguity of surface, and thereby the number of symptoms as well as the extent of disease be increased.

At present we can only make a diagnosis of spastic spinal paralysis. We cannot be certain, during life, that the disease in the lateral columns is primary, nor that it is altogether limited to that part of the cord.

Prognosis.—When uncomplicated the disease does not appear to shorten life. It is sometimes capable of improvement, and even cures have been reported.

Treatment.—The treatment applicable in these cases is that usually adopted in locomotor ataxia and other forms of chronic myelitis. Rest in bed for a number of weeks, especially when there seems to be an exacerbation of the disease, may produce amelioration of the symptoms. Hydrotherapy in its various forms, sponge-baths, wet packing, cold, and in some instances hot, baths, deserves trial. Electricity is the therapeutic agent in most common use, and, perhaps, of greatest power. Both the galvanic and faradic currents may be tried, and applied to the paralyzed muscles as well as over the spine. Probably most can be hoped from the central application of the constant current.

Various drugs have been administered. Probably the greatest reliance has been placed upon nitrate of silver, and, especially when there has been an antecedent syphilitic history, iodide of potash.

(*b*) Amyotrophic Lateral Sclerosis.—For both the description of the symptoms and knowledge of the anatomical character of this disease, we are chiefly indebted to Charcot. Though somewhat akin to the disease just described, it presents striking differences both in its symptomatology and morbid anatomy. It occurs chiefly in persons of middle age, but has been observed in children.

Symptoms.—The disease usually begins with paralysis of the upper extremities, which is soon accompanied by atrophy and fibrillary contractions of the paralyzed muscles. Subsequently muscular rigidity and contractures occur, the arms assuming the position found in spastic paralysis, partly flexed at the elbows and pressed against the body, forearms pronated, hands and fingers strongly flexed. These contractures may remain even when the muscles are almost completely atrophied. Usually, after the lapse of a number of months the lower extremities become involved. In them the manifestations are mostly like those of spastic paralysis—paralysis, exaggerated tendon reflexes, muscular rigidity, contractures—while little or no atrophy of the muscles is observed. The electrical reactions are altered according to the degree of muscular atrophy. In the lower extremities there may be a mere quantitative change, diminution of electrical irritability, while in the upper extremities the alteration is usually more marked, and, when the muscular atrophy is rapid, as often occurs in the small muscles of the hand, typical reaction of degeneration may be found.

At a still later period bulbar symptoms, those of glosso-labio-laryngeal paralysis—atrophy of the lips and tongue, difficulty in deglutition, indistinct speech, respiratory disturbances—appear, and finally carry off the patient.

The symptoms do not always appear in the order described. Sometimes the disease begins in the lower extremities, extending thence to the upper, and finally to the cranial nerves. Sometimes the disease begins as a bulbar paralysis, though it need not, therefore, run a rapid course.

The degree to which spastic symptoms, and to which muscular atrophy appear in both upper and lower extremities is also quite variable, depending upon the part of the nervous system in which the morbid changes began, and upon the extent to which the gray and white nervous tissues are respectively affected.

The duration of the disease is usually from one to three years. The well-marked cases hitherto recorded terminated fatally. Death is generally caused by the bulbar symptoms.

Morbid Anatomy and Physiology.—The morbid changes are almost, if not altogether, limited to the motor central and peripheral nervous apparatus. There is sclerosis—

atrophy of the nerve-fibres and increase of the connective tissue—of the direct and crossed pyramidal tracts in the cord, often extending above the crossing of the pyramids in the medulla, and in two cases of Charcot and one of Koshewnikow, the morbid changes could be followed to the cortical motor area in the upper half of the central convolution. There is atrophy of the large ganglion cells of the anterior cornua, and of the cells of the nuclei of the affected cranial nerves. Certain of the cranial nerves, of the anterior roots of the spinal nerves, of the mixed nerves, and of the muscles, are also found in various stages of atrophy.

As to the explanation of the symptoms, the muscular atrophy is due to the atrophy of the large ganglion cells, the bulbar symptoms to disease of the nuclei of the cranial nerves, the spastic phenomena to sclerosis of the pyramidal tracts. The preponderance of spastic or atrophic manifestations is due to preponderance of the morbid process in the white or gray matter, respectively.

Diagnosis.—The diagnosis must be based on the order of appearance of the symptoms, but chiefly upon the combination of spastic and atrophic phenomena. An early diagnosis is often impossible—for instance, to distinguish the disease, when it begins with bulbar symptoms, from ordinary glosso-labio-laryngeal paralysis. But some pathologists have considered these and some other chronic affections as really the same process, only in varying degrees of development.

The prognosis is sufficiently indicated in the foregoing description. Such treatment may be resorted to as is employed in other chronic diseases of the cord.

Philip Zenner.

SPINAL CORD DISEASES: MENINGEAL HÆMORRHAGE. Definition.—Spinal Meningeal Hæmorrhage, Hæmatorrhachis, Spinal Meningeal Apoplexy, is a hæmorrhage into the spinal canal in, between, or about the membranes of the spinal cord. As an uncomplicated affection it is of rare occurrence, but in cases of traumatism it is often associated with injuries of the cord itself.

Varieties.—The hæmorrhage in spinal meningeal apoplexy may be either extra-dural, *i.e.*, outside of the dura mater, in the loose connective tissue between that membrane and the bony walls of the canal, or sub-dural. In the latter, the hæmorrhage may be inter-arachnoideal, between the layers of the arachnoid, as formerly believed, or sub-arachnoideal, in the connective tissue between the arachnoid and pia mater, on the surface, or in the meshes of the pia mater, or on the surface of the cord itself.

Pathological Anatomy.—In extra-dural hæmorrhage the blood is effused on the outer surface of the dura mater and in the loose connective tissue outside of that membrane. The effused blood, unless excessive in amount, is, as a rule, coagulated, and limited in longitudinal extent to the length of two or three vertebræ; it may surround the whole cord in the form of a ring, or be located on the anterior or posterior surface of the organ, more often the latter; it follows, as a rule, the nerve-roots arising from the affected region.

The dura mater and tissues around are stained, ecchymosed, and covered with clotted blood, to a greater or less depth. When there has been any compression of the cord or of the nerve-roots, these are found red and softened at the injured spot, and bloodless beyond. The spinal fluid is dark and turbid. The bloody effusion is more often limited to one spot, but it may occur in several places, and it may be so profuse as to fill up the whole spinal canal. This form of meningeal hæmorrhage is the most common, comprising about three-fourths of the reported cases.

In sub-dural hæmorrhage, the inter-arachnoideal of some authors, the blood is generally fluid, sometimes, however, coagulated, and lies loosely between the dura mater and arachnoid. In this form, which is rare, the source of the hæmorrhage is cranial or from rupture of spinal vessels. Hæmatoma of the spinal dura mater, pachymeningitis hæmorrhagica, is, of course, not included. Pigmentation and ecchymoses of the meninges, with secondary inflammation, form the only pathological changes to be observed.

In the sub-arachnoideal form the blood is diffused and coagulated beneath the arachnoid, in the loose connective tissue, or between the meshes of the pia mater and on the surface of the cord; encircling, either totally or partially, that organ. In longitudinal extent, the effused blood is limited generally to the length of two or three vertebræ, and it may be found at two or more places. The membranes are stained and ecchymotic, and the cord is reddened at the affected spot, but there is little, if any, compression; the spinal fluid is colored.

The inflammatory signs following spinal meningeal hæmorrhage are very limited, and consist in thickenings, adhesions, and pigmentation of the membranes.

Etiology.—The causes of simple uncomplicated hæmorrhage into the spinal meninges are not very well known. The peculiarity of the circulation in the spinal canal, in which a number of small vessels anastomose very freely, and so diminish the tension of the blood-column and equalize the pressure, does not favor its occurrence; and again, the degeneration of the coats of the vessels, which we see playing such an important part as a factor in cerebral hæmorrhage, does not seem here to obtain so easily and is never so pronounced. Age does not seem to predispose in any way to it, and though the greater number of cases are found among men, this does not appear to be due to any particular susceptibility, but rather to the greater exposure to traumatism of that sex.

Among the exciting causes traumatism is by far the most frequent; to be brief, fractures and dislocations of the vertebral column, blows, and falls on the buttocks or feet causing concussion of the column, deserve to be specially mentioned. Syphilitic caries of the vertebræ, and the rupture of thoracic or abdominal aneurisms into the spinal canal, have been shown to have caused the affection in some cases. The rupture of spinal vessels, either from degeneration of their coats or from other causes, and the gravitation of the blood in cranial hæmorrhages, have been regarded as etiological factors in several cases. The sudden cessation of the menstrual flow, or hæmorrhoidal flux, violent bodily exercise, and the rupture of vessels in eclampsia, tetanus, and other spasmodic diseases, are believed in certain cases to be able to produce the affection. Finally, post-mortem examinations have shown that spinal meningeal apoplexy does occasionally occur in the course of long and protracted diseases, such as scurvy, purpura, typhus and typhoid fever, pyæmia, yellow fever, hæmorrhagic malarial fever, etc.

Symptoms and Clinical History.—The symptoms caused by hæmorrhage into the spinal meninges will vary according to the locality affected, and the amount of the hæmorrhage. The onset is, as a rule, sudden, though in exceptional cases it may be preceded for a day or two by feelings of languor, stiffness of the back and neck, and other indefinite symptoms. The most prominent symptoms are a sudden tearing pain in the back, at the site of the lesion, followed or accompanied by various symptoms denoting irritation, both of the motor and sensory nerve-roots, and of the spinal meninges. These are stiffness of the back, neck, and limbs, increased upon motion; jerking, spasmodic contraction of the muscles, neuralgic pains, numbness, formication, and hyperæsthesia of the parts. These irritative symptoms are soon followed by others of paralysis and anæsthesia, but these are, as a rule, never complete. The bladder and rectum are little, if at all, affected; the mind is clear except in cases in which the shock is very great. The inflammatory reaction which follows is generally of short duration, seldom lasting more than a day or two, and the fever and general symptoms are, on the whole, mild.

The symptoms are more or less modified, according to the segment of the cord affected. When the hæmorrhage occupies the cervical region, the pain and stiffness, together with the hyperæsthesia, are more marked, and sometimes altogether confined to the upper extremities and neck; the breathing may, or may not, be disturbed,

according as the root of the phrenic nerve is implicated or not; interference with the cilio-spinal centre will cause flushing of the face and neck, and dilatation of the pupils, followed by paleness of the parts and contraction of the irides.

When the lesion is situated in the dorsal region, the stiffness and pain are limited to that region of the back and a distinct girdle sensation is complained of; the patellar and other reflexes in the lower extremities are increased.

When the lumbar portion is affected, the symptoms are referred to the buttocks, perineum, and genitals, and the bladder and rectum are, as a rule, partially paralyzed. The tendency of the affection is toward recovery, but that may sometimes be protracted. Death is not rare in excessive hæmorrhages or in complicated cases.

The following case is selected from several in my note-book, and serves to illustrate clearly the affection.

H. B——, aged thirty-three, a car-driver by occupation, drinks and smokes moderately, has never had syphilis, gives no family history of disease, has been subject to bleeding piles for years. About July 1, 1886, he had an attack of diarrhœa, followed by costiveness, and from that time the bleeding from the hæmorrhoids ceased. On July 3, about 9 P.M., he was sitting on his car, wet with perspiration, exposed to a rather cool breeze, when he felt a sudden tearing pain in the back, in the upper lumbar region; he tried to get up, but his legs became stiff and shaky, and he could not move them; the affected parts were numb; he could not bear to have them touched, and he felt as if ants were creeping up his feet. In this condition he was taken home on a stretcher, the least motion of his back increasing the cramps and spasms in his legs, and giving rise to shooting pains. On the next day he had slight fever, and his other symptoms grew worse; he could not move the legs at all, and could not bear to have them touched; there was retention of urine, with dribbling; the bowels were costive.

The patient was admitted in the ward for nervous diseases of Charity Hospital on July 7, 1886, when the following notes of the case were made: General appearance good; pulse, 108; temperature, 99½° F.; respiration, 22. He complains of great pain, increased upon pressure and motion, over the lower dorsal and first lumbar vertebræ, and of a girdle-feeling around the abdomen at about the level of the anterior-superior iliac spine; the lower extremities are well nourished, but almost completely paralyzed; the muscles are flaccid, the bladder is unable to retain urine for any length of time, but the patient has time to call for assistance, and so keeps from wetting his bed; the bowels are costive; sensation, both general and tactile, in the affected part is very much lessened, and feelings of formication and numbness still persist. The patellar tendon reflexes are greatly diminished, scarcely perceptible. The mind is clear, and the upper extremities are normal. He was put on a mixture of five grains of iodide of potassium and thirty drops of the fluid extract of ergot every three hours; small doses of morphine, with large doses of bromide of potassium, were given two or three times during the night to relieve the pain in the back and the crampy feelings which, he said, were always worse at that time; counter-irritation by means of tincture of iodine was made along the vertebral column every other day.

On August 29th the pain in the back and the muscular spasms had greatly subsided; the patient could lie on his back and permitted himself to be moved; he had some power in the lower extremities, but could not lift his feet from the bed; the anæsthesia still persisted, though somewhat ameliorated; the formication and numbness were lessened; the bladder and rectum were normal. Electrical examination made at this time showed lessened galvanic and faradic irritability. Counter-irritation was then stopped and mild galvanic currents to the spine were begun, and the faradic current was applied to the affected extremities. Iodide of potassium was continued in ten-grain doses three times a day. In the latter part of September the patient was able to stand on his legs, the feeling in those parts slowly returning; formication had disappeared, and, aside from a slight numbness, the parts felt well.

From that time the patient slowly improved until December 18, 1886, when he was discharged as cured.

DIAGNOSIS.—The suddenness of the attack, the acuteness of the pain, the symptoms of irritation first, soon followed by mild symptoms of paralysis, the moderation of general symptoms and the rapid subsidence of the same, and the tendency to improvement and recovery, make simple uncomplicated cases of spinal meningeal hæmorrhage in most instances easy of diagnosis. The affections with which it is most likely to be confounded are the following: Spinal meningeal congestion, medullary hæmorrhage, spinal meningitis, myelitis, and simple concussion. In hyperæmia of the spinal meninges the symptoms come on gradually and are not constant, remissions occurring at different periods of the twenty-four hours.

In medullary hæmorrhage (spinal apoplexy) the symptoms of paralysis and anæsthesia are sudden and complete, and the tendency to spasms is altogether absent. Death is rapid, or incurable paralysis is the result.

Meningitis and myelitis can generally be recognized by their slower evolution, by the high fever, and by the general symptoms.

In simple concussion spasm is generally wanting, and the symptoms of paralysis come on early.

PROGNOSIS.—The prognosis depends on the amount of hæmorrhage and on the seat of the lesion. When the hæmorrhage is small, the causal injury slight, the inflammatory and reactive symptoms mild, the paralysis not too extensive and profound, and the patient young, the prognosis, as a rule, is favorable. But when, on the contrary, the shock is great and the hæmorrhage profuse, when the cervical region is implicated, the paralysis profound, and the fever and general symptoms severe, the prognosis is correspondingly bad. The affection, however, lasts for several months, even in the most favorable cases.

TREATMENT.—The treatment should at first be directed to the limiting of the hæmorrhage and the diminution of the reactive symptoms. For the first purpose, absolute rest in bed, on the side or on the abdomen, the internal and hypodermic administration of ergot in half-drachm or drachm doses every hour or two, or of ergotine in large doses, tincture of belladonna to the full physiological limit, cold applications to the back by means of ice-bags or otherwise, the local abstraction of blood by means of cupping, leeches to the back of the ear or to the anus, and, in plethoric subjects venesection, hot applications to the extremities, and repeated drastic purges, are to be recommended. To meet the second indication, cooling drinks and mild antipyretics are of service. Later on, the reabsorption of the effused blood should be facilitated, and the anæsthesia and paralysis properly treated by means of counter-irritation to the spine by iodine, blistering, or dry cupping; by the internal administration of the iodide of potassium in large doses, massage, passive exercise, the use of electricity, both galvanic and faradic, and the administration of small doses of mercury and general tonics.

If pain be present, narcotics are naturally indicated; to relieve spasms, the bromides and chloral hydrate are of great value.

Much can be done to prevent the affection by proper treatment of suspended menstrual and hæmorrhoidal discharges, and by relieving hyperæmia of the cord.

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SPINAL CORD DISEASES: MULTIPLE (CEREBRO-SPINAL) SCLEROSIS. Synonyms: Disseminated sclerosis; insular sclerosis.

DEFINITION.—This disease may present manifold symptoms, the most common of which are paresis, with muscular rigidity and exaggerated tendon reflexes as in spastic paralysis, tremor brought on by voluntary movements, nystagmus, scanning speech, amblyopia, apoplectiform attacks, and impaired intellect. The anatomical basis of the disease consists of disseminated patches of sclerosed tissue in various parts of the central and peripheral nervous systems.

ETIOLOGY.—An hereditary influence has been traced in a few instances. Charcot states that the disease occurs most frequently in females, but a number of other observers do not concur with him in this view. It occurs most frequently between the ages of fifteen and thirty; occasionally in young children; rarely, if at all, after forty.

Traumatic influences, such as blows on the head, concussion of the whole body, exposure, hardship, overwork, and profound emotional disturbance, may all be mentioned as occasional exciting causes. In a number of instances the disease developed after the existence of an acute disease, typhoid fever, variola, etc.

SYMPTOMS.—The areas of diseased tissue may involve any part of the nervous system and may occur in any number, while the disease may be of various degrees of severity; and the symptoms, which are but the expression of the locality and intensity of the disease, may make the most varied clinical pictures. There may be an entire absence of symptoms of disease of the nervous system, though sclerosed nodules are found post mortem; or the disease may simulate various different organic or functional nervous diseases. But, nevertheless, the sclerosis seems to have a predilection for certain parts of the nervous system, and we find, accordingly, in many cases similar, and almost characteristic, clinical appearances.

A cerebral and a spinal form of multiple sclerosis are sometimes spoken of, but usually both brain and cord become involved in the disease, though it may have been present in the one some time before it was in the other. Generally the spinal cord is first affected.

The disease usually begins very insidiously and is slow in its progress; in rare instances it has an abrupt beginning, perhaps is ushered in by an apoplectiform attack. The earliest symptoms may be of cerebral origin, such as headache, vertigo, ataxic gait, and slight psychic disturbances; or there may be a slight tremor in one or both hands; but more frequently the symptoms are those of spastic paralysis.

At first there is weakness of one leg, then of both, attended by some difficulty in walking. Gradually, with increasing paresis of the limbs, there appear muscular rigidity, especially brought on by active or passive movements, exaggerated tendon reflexes, spastic gait, and, finally, rigid contractures of the limbs. The paresis, and, to a less extent, muscular rigidity, etc., at a later period affect the upper extremities, and to these is subsequently added another motor symptom—one of the most prominent and characteristic of this disease—the so-called intention tremor, tremor during the performance of a voluntary act. Before it is otherwise noticeable, it may be observed in the handwriting or other delicate movements of the fingers, especially if the act is slowly performed. The writing, if carefully observed, will be seen to be full of small indentations which occur with great regularity, indicating that the tremor is rhythmical. When the tremor is well marked any voluntary movement will cause it to appear, and it may be seen to some extent during rest. A common method of eliciting the symptom is to ask the patient to put a glass of water to his lips. The tremor increases and the oscillations of the hand are greater as the latter approaches the mouth. The trembling may become so violent that the water is thrown out of the glass and the effort proves futile. When the patient is sitting quietly either there is no tremor, or slight movements of the head and trunk may be observed. If he now perform a voluntary act, as lifting an arm, the tremor in the head and trunk increases at the same time that there is tremor of the acting member. When he attempts to walk there may be such violent tremor of the limbs and trunk as to make walking, or even standing, almost impossible. On the other hand, when the patient lies down and every part is well supported no tremor appears. None is observed during sleep. It is increased by emotional excitement.

All the voluntary muscles may be thus affected, the head as well as the trunk and limbs. Tremor in the face is less commonly seen, though there may be irregular movements, choreic in character.

The distinctive features of the tremor are that it is rhythmical, and that it occurs only with muscular efforts. A very few cases have been reported where it continued even in rest, but such cases are exceedingly rare. The tremor is not found in all cases. It probably depends on the locality of the disease. It also disappears in any part when the latter has become completely paralyzed.

The tremor can usually be easily distinguished from that of other diseases. In paralysis agitans, in the beginning (and it is only then that the two diseases could easily be confounded), only a few fingers are affected, and the oscillations are fine and very rapid. At the same time the tremor has somewhat the character of co-ordinated movements. Thus the movement of the thumb upon the fingers has been likened to that of counting money, rolling pills, etc. The tremor of multiple sclerosis is large and coarse, with no appearance of co-ordinated action. In paralysis agitans, furthermore, the tremor is, to some extent, controlled by voluntary movement, and increases with rest, and the head is very rarely affected. When the tremor is violent it may have the appearance of the movements of chorea. But the latter occur during repose as well as during volitional acts, and they cause an intended movement to be made very irregularly; on the other hand, in multiple sclerosis the general direction of any movement is maintained, but the line of movement is an undulating one, the undulations playing equally up and down along the central line of direction.

The next two symptoms seem to be similar in character to the tremor. The first is nystagmus, a very common symptom, and of value in diagnosis. When not otherwise noticeable, it may be made manifest by movements of the eyes, strong convergence, or forced movements in some direction. The other symptom is scanning speech. Other changes of speech are sometimes present, but this is the most common and most characteristic, and, therefore, of high diagnostic value. The speech is slow and dragging, each syllable being pronounced separately as in the slow scanning of verse, and, therefore, termed scanning speech. If the patient attempts to speak more rapidly, his words are likely to be so jumbled together as not to be at all understood. The voice is monotonous to the highest degree. There is often tremor of the lips at the same time, and, on laryngoscopic examination, there has been found to be diminished tension of the vocal cords.

Other ocular symptoms besides nystagmus are frequently found. Double vision, due to paralysis of some of the external muscles of the eye, occurs, just as in locomotor ataxia, either as a transient symptom at an early period of the disease, or as a permanent condition at a later stage. Amblyopia is also a common symptom. Generally there is only impaired vision, not complete blindness. The ophthalmoscope reveals, in these cases, a discoloration of the disks, due to a degree of atrophy of the optic nerves.

Headache and vertigo are often present, both in the early and in the later stages of the disease. The vertigo often occurs in paroxysms. Occasionally it is due to the double vision, but more frequently it is quite independent of the latter condition.

The mental symptoms often play an important rôle. Slight psychic symptoms may be manifested in the beginning of the disease if the latter first affects the brain, but the graver symptoms are, usually, late manifestations

Change in disposition, irritability, loss of self-control, a tendency to laughing and crying, are common conditions. A certain impairment of intellect—weakened memory, a degree of apathy, etc.—is, also, not uncommon. But a high degree of dementia is rare. It is only likely to occur when the disease begins at an early age and there is arrested development of the brain, or when the pathological process is very acute. Different forms of insanity are sometimes observed, most frequently melancholia, occasionally delusional insanity.

Apoplectiform seizures, like those seen in general paralysis, are important symptoms. They occur, according to Charcot, in one-fifth of all cases. After slight prodromal symptoms, headaches, etc., coma develops within a few hours, the temperature rapidly rises, often reaching 104° or 105° F., and at the same time the face is flushed and the pulse rapid. Hemiplegia, with flaccidity of the paralyzed muscles, is soon observed. Within a day or two consciousness returns, the temperature falls, and, within a comparatively brief period, the paralysis disappears. Such attacks may occur every few months, or very rarely. They usually leave the patient in a permanently worse condition, thus marking the progress of the disease. Sometimes the patient dies in the attack. These seizures are very much like those of apoplexy, but post-mortem examinations reveal no anatomical basis for them.

In the foregoing have been given the most common symptoms of multiple sclerosis, those found in the majority of cases. But, on account of the distribution of the diseased areas, various other symptoms may be manifested. Thus the disease may attack the posterior columns of the cord, and ataxia, pain, anæsthesia, paræsthesia, etc., will be present; or it may involve the gray matter, when atrophy and paralysis of muscles will ensue. Or the disease may involve the whole thickness of the cord and produce the symptoms of transverse myelitis. When the posterior as well as the antero-lateral columns are affected, many of the appearances of spastic paralysis are likely to be absent, especially the exaggerated tendon reflexes. Symptoms referable to the bladder, rectal, and genital functions are also likely to appear. If the disease involve the nuclei of the facial, hypoglossal, and pneumogastric nerves, the ordinary symptoms of labio-glosso-laryngeal paralysis will be manifested, and various local cerebral symptoms may appear, according to the location of the foci of disease.

The course of the disease is a very chronic one. Charcot has divided it into three stages—a division applicable to those cases which present the common clinical picture.

The first stage is from the beginning of the disease to the period of complete disability from paralysis and contractures of the limbs. This stage may last from two to six years or longer. The symptoms are very slow in their progress. They begin as spinal or cerebral, but both sets of symptoms appear before this stage is terminated. There is often an arrest of the symptoms, or even improvement, which indefinitely prolongs this stage, and may give rise to delusive hopes of complete restoration to health.

The second stage, that of the fully developed disease, may last also from two to six years. There seems to be little change in the patient during this period, and, though entirely helpless, he seems not to suffer in general health.

The third stage is that of decline. The general health is affected, there is loss of appetite, wasting, etc. Cystitis, decubitus, pyæmia, etc., may hasten the end. Or the latter may be due to an increase in the bulbar symptoms, or to an apoplectiform attack. More frequently a fatal termination is caused by an intercurrent affection—pneumonia, typhoid fever, or, above all, phthisis.

The average length of the disease is from six to eight years. In rare cases it terminates in a year or two. Occasionally it lasts twenty years.

Morbid Anatomy.—The pathological changes can usually be seen by the naked eye. They consist of numerous patches or nodules of sclerosed tissue scattered throughout the nervous system. The nodules vary in size from merely microscopical proportions to that of a chestnut or larger, are rounded or irregular in shape, and may often be seen on the surface as slight prominences or depressions, but are found in larger number on making sections of the brain and cord. Their color is mostly of a gray or reddish-gray; they are translucent, and have a firm, often cartilaginous, consistence. Many of the nodules are of the same color as the surrounding tissue, and are only distinguished by their consistency. In rare instances a few may be softer than the normal tissue, probably indicating recent disease; most of the nodules, on the other hand, doubtless being of very old standing, for such cases come to the post-mortem table only after the disease has existed a long time. The nodules seem to be quite distinctly circumscribed, but the microscope reveals that they merge imperceptibly into the healthy tissue. They are also quite distinct, as a rule, though occasionally they blend into one another. In rare instances there has been found a diffuse sclerosis in both the brain and cord, which, to some extent, has united the scattered nodules. On the other hand, secondary degeneration seems rarely, if at all, to develop from the disseminated disease.

The number of nodules found in a single instance may be very small, or may run into hundreds. Their distribution in the cord is very irregular. In some sections they may be found in the anterior, in others in the posterior, columns; in still others in the gray matter, or they may involve all these parts in the same section. Usually a large number of nodules are found in the medulla, pons, and crura cerebri. It is very rare that these parts are found free from disease. In the hemispheres the walls of the ventricles, corpus callosum, and centrum ovale are favored seats of the disease. In the latter two localities the nodules are often quite large. Usually nodules are also found in the large ganglia, while the cortex generally escapes. But few nodules are, as a rule, found in the cerebellum, and those in the central white matter. Similar nodules may be found in the nerves, most frequently in the optic nerves, but occasionally in the hypoglossal, the nerves of the eye, and the roots of the spinal nerves.

The microscopical appearances are those of interstitial myelitis. The nodules are mostly new connective tissue composed of very fine wavy fibrillæ. But in this new tissue the axis-cylinders of the nerve-fibres can usually be found in large numbers, though their medullary sheaths have disappeared. This is especially true of the nodules in the spinal cord.

At the last meeting of the Society of German Naturalists and Physicians, Adamkiewicz expressed the opinion that the disease is not interstitial, but develops primarily in the nervous tissue, beginning in the medullary sheaths of the nerves. He bases his opinion upon results obtained by a new method of staining the nervous tissue. His view is altogether at variance with that formerly held, and may be looked upon with doubt, at least until further corroboration.

Morbid Physiology.—Many of the symptoms are easily explained by the lesions found: psychic symptoms by disease of the hemispheres, bulbar symptoms by lesions of the medulla, muscular atrophy by lesions in the anterior cornua, anæsthesia and ataxia by disease of the posterior columns, spastic paralysis by disease of the antero-lateral columns—in some instances cerebral lesions may produce the same symptoms—while amblyopia and some other symptoms are often due to nodules in the nerves themselves.

The long retention of the axis-cylinders accounts for the usual presence of paresis rather than paralysis, for the anæsthesia being slight, the amblyopia rarely advancing to complete blindness, etc. (In locomotor ataxia there are also numerous axis-cylinders in the sclerosed area, and the symptoms usually point to only a partial loss of function.) Charcot attributes the tremor to the same condition. He supposes that the axis-cylinders continue to carry voluntary impulses, but, because they are bared of their medullary sheaths, they carry them

Spinal Cord.

in an irregular, jerking manner, and hence the oscillations in the voluntary movements. While this must be considered a mere theory, we can speak with more positiveness of the location of the lesion as a cause of the tremor. It seems to be due to nodules in the medulla and pons, or, at least, in the basilar portions of the brain. In a few cases where the disease was limited to the cord no tremor was observed. On the other hand, when tremor was observed during life, nodules were always found in the medulla and pons; when it was not observed, these parts were not affected to any extent.

With a considerable degree of doubt, we may attribute the nystagmus to lesions in the corpora quadrigemina, the scanning speech to lesions in the medulla, the vertigo to lesions in the medulla or cerebellum. A satisfactory explanation of the apoplectiform attacks has not yet been given.

Diagnosis.—In some instances a diagnosis is made with the greatest ease, in others it is almost impossible. The most common clinical picture—paresis of the extremities with exaggerated tendon reflexes, intention tremor, nystagmus, scanning speech, amblyopia, etc.—is so characteristic that it cannot be mistaken.* But some of the most characteristic symptoms may be wanting, and then the diagnosis is much more difficult. In this case the indications of multiplicity of lesions, and the very chronic course of the malady, must be the guides to diagnosis. When the disease is limited to the spinal cord one can scarcely do more than guess in distinguishing it from other forms of myelitis. In such cases one must be on the lookout for cerebral symptoms. Optic atrophy is often a valuable diagnostic symptom, not only in this instance, but in excluding hysteria or other functional diseases which may simulate multiple sclerosis.

When the sclerosis affects only the brain it may present some of the appearances of brain tumor. Here, too, the indications of a multiple lesion, and the very slow course of the disease, may clear up the diagnosis. But there is another important distinction, in that brain tumors produce to a large extent general symptoms, those of intracranial pressure, such as severe headache, convulsions, and double optic neuritis; while sclerosis produces merely local symptoms, those indicating the loss of function of the part affected by the disease.

The tremor of alcohol, lead, and mercurial poisoning might be mistaken for this disease, but concomitant symptoms and the history of a cause will establish the diagnosis. The tremor of paralysis agitans, with which this disease was formerly confounded, is easily distinguished by the appearance of the tremor, its being controlled to some extent by voluntary effort and increased during rest, and its very rarely affecting the muscles of the head and neck. Furthermore, paralysis agitans is rarely found in persons under forty years of age, while multiple sclerosis rarely occurs after thirty, and, apart from the tremor, the symptoms of the two diseases are quite different.

Prognosis.—Charcot believes that the disease may sometimes be cured, but the opposite view is generally entertained, though its arrest, and even improvement, for a number of years has been observed. It usually runs a very protracted course. When at its inception it manifests itself in various parts of the nervous system at the same time, it is likely to run a more rapid course. The occurrence of apoplectiform seizures, cystitis, bulbar symptoms, etc., hastens the fatal termination.

Treatment.—The same treatment is applicable as in other forms of chronic myelitis, for which see Lateral Sclerosis. *Philip Zenner.*

SPINAL CORD DISEASES: PROGRESSIVE MUSCULAR ATROPHIES. With our increasing knowledge of progressive muscular atrophies the subject is constantly acquiring greater and greater complexity. What was apparently a single, homogeneous condition, has resolved itself, on closer investigation, into a number of apparently distinct affections.

The disease commonly known as progressive muscular atrophy was first described in 1850 by Duchenne and Aran, who regarded it as an independent affection of the muscles. In 1853 Cruveilhier obtained an autopsy on a case of this disease, and was led by what he there found to regard it as the result of atrophy of the anterior roots of the spinal nerves. In 1860 Luys first discovered an atrophic condition of the ganglion cells in the anterior horns of the gray matter of the cord, corresponding to the atrophied nerve-roots, and since that time the myelopathic (spinal) theory of the disease has been the prevailing one. In the past few years, however, the pendulum has swung in the opposite direction, and there is now a strong tendency to the adoption of Friedreich's theory, that all these forms of muscular atrophy are myopathic in origin, and that spinal lesions, when present, are secondary to changes in the muscles.

A comprehensive view of the subject can be obtained by adopting Seppili's classification. He divides progressive muscular atrophies (amyotrophies) into the following classes:

A. *Neuropathic.*—1. Peripheral (toxic, infectious). 2. Central (myelopathics). *a.* Progressive muscular atrophy. *b.* Amyotrophic lateral sclerosis. *c.* Deuteropathic spinal amyotrophies (from extension of disease to the anterior horns).

B. *Myopathic.*—Progressive muscular dystrophy, or progressive primary atrophy. *a.* Infantile progressive muscular atrophy. *b.* Erb's juvenile form of muscular atrophy. *c.* Muscular pseudo-hypertrophy. *d.* Leyden's hereditary muscular atrophy. *e.* Transitional forms.

In the following paper we shall adopt this classification, with slight modifications.

For the sake of convenience we will begin with the consideration of progressive muscular atrophy of spinal origin.

Spinal Progressive Muscular Atrophy. *Etiology.*—This affection, when uncomplicated, occurs in males in the large majority of cases. It is proportionately more frequent in the female sex when it is associated, as so often happens, with bulbar paralysis. Among 16 uncomplicated cases of which the writer has kept notes, all except one occurred in men. Among 214 cases collated by Friedreich and Eulenberg, 167 occurred in males, 47 in females. This great disproportion between the sexes is, perhaps, owing to the fact that males are more exposed to the exciting causes of the disease.

The disease begins most frequently between the ages of thirty and fifty years. Of the writer's 16 cases 3 began before the age of thirty years, 12 between thirty and fifty years, and 1 patient was nearly sixty years of age.

A great many cases have been reported in which heredity seemed to play an important part in the etiology, but the majority of such cases date back to the time when the differentiation between this and other forms of atrophy was not made very carefully. It is very probable that the majority, if not all, of these hereditary cases really belong to the myopathic class of atrophies. Cases seem to be more numerous in families in which there is a neuropathic tendency, but even this has been rarely observed in the cases under my own observation.

Among the exciting causes may be mentioned prolonged exposure to damp and cold, mental depression, syphilis, infectious diseases, and excessive work. Traumatism sometimes appears to determine the occurrence of the disease in the injured part. A few cases have been seen in which it followed a concussion of the spine.

The action of these exciting causes is not very important. They would probably prove inefficient were it not for the existence of some predisposing etiological factor whose nature is entirely obscure, and in many cases they are probably mere coincidences.

Symptomatology.—In the majority of cases the disease begins in the small muscles of one hand. The patient finds that he is gradually growing less able to execute

* Schuler reported a case of tumor of the right hemisphere, in the neighborhood of the island of Reil, which produced the typical clinical picture of multiple sclerosis, and Westphal reported two cases with similar histories, in which no pathological changes were found post mortem. But these are such rare occurrences as not to materially impair the diagnostic value of this clinical picture.

voluntary movements with the fingers, and at the same time the muscles undergo wasting *pari passu* with the loss of power. Then the paralysis and wasting spread to the forearm, usually implicating the flexors and extensors, and, next, the arm or shoulder of the same side. The other arm is then affected in a similar manner, but sometimes the disease appears in both arms almost at the same time. As the disease progresses the atrophy may attack the muscles of the back and lower limbs, the former being less severely affected, as a rule, than the other parts. The muscles of the face remain intact, except in those cases that are complicated with progressive bulbar paralysis. The wasting may be so extreme that the affected limbs finally seem to consist merely of skin and bone. Fibrillary contractions of the muscles are a very constant symptom in the parts affected. A fibre is seen to contract quickly, then the contraction subsides, and again appears in the same or an adjacent fibre. When the disease is widespread these contractions are sometimes visible over a large part of the body. They may be seen in apparently healthy muscles, and then usually indicate the impending affection of these muscles. The mechanical excitability of the muscles is also very often increased.

The atrophied muscles present various electrical reactions. Sometimes there seems to be merely a simple diminution of faradic and galvanic excitability. Careful examination, however, will generally reveal evidences of partial or complete degeneration reaction (usually the former) even at a very early stage of the disease. The attention should be chiefly directed to the rapidity of contraction. On account of the intermingling of healthy and degenerated fibres in the same muscle, the normal contractions of the former may hide the abnormal mode of contraction of the latter, but on making the current sufficiently weak the slowness of contraction is often made evident. AClC is often stronger than CClC.

Cutaneous sensibility remains unaffected during the entire course of the disease. At the most the patients complain of a sense of numbness in various parts, usually the hands, or of a feeling of soreness or slight pain. Trophic disturbances in the skin and deeper parts are rare. The functions of the bladder and rectum remain intact until the end.

The disease advances slowly, with alternate exacerbations and remissions, until the patient is reduced to a condition of absolute helplessness, and dies from exhaustion or from some intercurrent disease. The affection may last from ten to twenty-five years, or even longer.

We will now discuss the symptomatology more in detail.

In a few cases the onset of the disease is preceded by slight aching pain in the parts which are subsequently the first to be attacked, by a feeling of numbness which comes and goes, or by a sensation of coldness. When pain, or other sensory prodromal symptoms are prominent, it is doubtful whether the case should be regarded as one of pure progressive muscular atrophy.

In the majority of cases the disease begins in the small muscles of the hands, usually on the right side. The thenar eminence is the first to be attacked; its normal rotundity disappears and it becomes flattened. At the same time, or a little later, the interossei and hypothenar muscles are involved, the abductor indicis being especially liable to suffer. Unless the patient is obese, depressions then become noticeable in the interosseous spaces. The function of all these muscles is impaired *pari passu* with the wasting. The interossei adduct and abduct the fingers, and, at the same time, flex the first phalanx on the metacarpus, and extend the second and third phalanges. Hence paralysis of these muscles is followed by inability to adduct and abduct the fingers, and leaves the action of the long extensor and flexors of the fingers unopposed. This may result finally in the so-called "main en griffe," the first phalanges being hyperextended, the second and third phalanges strongly flexed. The resemblance to the claw-hand is increased still further when the lumbricales are attacked, as they usually are at a very early period. As a result of the wasting of these muscles the palm of the hand becomes hollowed out. The lumbricales simply aid the interossei in their action of flexion and extension, so that their paralysis increases the extension of the first phalanges, and flexion of the second and third phalanges.

From the hand the atrophy usually spreads to the forearm. In some cases the muscles seem to be attacked quite uniformly, so that the forearm atrophies as a whole. As a general thing, however, the extensors are first involved, the supinator longus usually escaping until the flexors or biceps are attacked, or even until a later period. From the forearm the atrophy extends commonly to the arm, to the biceps and brachialis anticus, while the triceps often remains comparatively intact for a long time. The various movements of the parts are enfeebled, according to the degree of the muscular wasting, but the power of flexion of the forearm on the arm is often retained long after atrophy of the biceps has taken place. The patient then effects this movement by the aid of the supinator longus, which is used as a flexor after the arm has been pronated. In those cases in which the deltoid remains intact the disproportion between the large shoulder and the shrivelled arm is very striking. The deltoid is the next muscle to be affected, though cases are quite common in which this is attacked immediately after, or even before, the hand muscles. Here it is very evident that the muscle is not attacked as a whole, but that certain fibres are picked out here and there by the process, which gradually spreads until finally no muscular tissue may remain. In some cases the atrophy begins in the deltoid, and makes considerable progress in this region before it attacks the small muscles of the hand. With the advancing affection of the deltoid the power of raising the arm from the side is gradually lost; but, even after the muscle is apparently destroyed, the patient is often able to move the arm from the chest, to a certain extent, by throwing the limb out suddenly, with the aid of the pectorals and trapezius, or by sudden movements of the trunk. The normal prominence of the shoulder is lost, the head of the humerus is felt immediately beneath the skin, and the finger can be pressed into the joint cavity. The other arm is usually attacked before the disease has made very much progress in the arm first involved, and the affection runs approximately the same course in both.

From the deltoids the disease spreads commonly to the pectorals, serratus magnus, the scapular muscles, latissimus dorsi, and the rhomboids. As a result of the atrophy of these parts the patient loses the power of rotating the humerus, raising the arm above the horizontal, or drawing the shoulders backward. These muscles are usually attacked at about the same time on the two sides. If the serratus magnus is more markedly atrophied than the other scapular muscles, the attempt to raise the arm beyond the horizontal line will be followed by marked separation of the scapula from the thorax (angel wing), so that sometimes the entire fist may be inserted between the posterior border of the bone and the chest-walls.

The deep muscles of the back and the abdominal muscles, particularly the former, are the next to be involved. The paralysis of the quadratus lumborum and erector spinæ gives rise to a marked lordosis; but whether this condition alone is responsible for the lordosis, as is generally believed, is more than doubtful. In a case at present under my observation, in which there is paralysis of the deep muscles of the back, there is marked lordosis in the erect position, the pelvis being tilted forward at the same time. When the patient sits down, the weight of the trunk thus resting on the tubera ischii, and tilting the pelvis backward, the spinal column is perfectly straight. When this patient bends forward to touch the ground while sitting down, the pelvis is tilted forward and the glutæi muscles are relaxed. On now making the effort to assume the erect position, the pelvis is felt to become vertical and the glutæi muscles at the same time become firm and contracted.

Atrophy of the abdominal muscles is usually not uniform, some parts of the muscles being affected more severely than others. The upper part of the rectus is often

intact, while the lower part of the muscle is very feeble. This condition is first shown by the inability of the patient, while in the recumbent position, to raise the trunk without the aid of the upper extremities. In the erect position there is marked lumbar lordosis, when the erectores spinæ are intact, from the unopposed action of these muscles; but a vertical line from the most prominent part of the spine falls within the sacrum. Vigorous expiration is impeded, and micturition and defecation are also interfered with when the abdominal muscles are wasted. The intercostals seem to be attacked much more often than the abdominal muscles. During inspiration the upper part of the thorax then remains motionless while the lower part is raised. Expiration is interfered with to a greater extent, because the upper two-thirds of the thorax are continually in the expiratory position. This is owing to the fact that the natural tendency of the thorax to undergo narrowing—as the result of the elasticity of the parts—is no longer opposed by the tonic contraction of the intercostals.

Paralysis of the diaphragm is usually a terminal phenomenon. After this occurs full inspiration is attended with sinking in of the epigastrium and hypochondria, and there is very little motion of the abdomen on expiration. The action of the intercostals and auxiliary muscles of respiration becomes exaggerated, unless these muscles are also paralyzed. The patient suffers constantly from dyspnœa, and life is jeopardized by the mildest affection of the respiratory organs.

According to the majority of writers, the muscles of the neck are attacked before those of the lower limbs. This has not occurred as a general thing in my experience. I have usually found that the lower limbs are attacked soon after the upper extremities. The muscles of the anterior leg group, or the extensor quadriceps, are usually involved first. Then the disease spreads to the muscles of the buttocks or calves, lastly to the posterior thigh group. In some cases, indeed, the disease appears first in the lower extremities. Paralysis of the anterior thigh group causes inability to extend the leg, and therefore interferes very materially with walking or rising from a sitting position. In paralysis of the anterior leg group the toes do not clear the ground in walking, and the thigh is therefore flexed more strongly at the hip, producing a very characteristic gait.

Among the muscles of the neck the extensors of the head are usually the first to be involved. As a result of this lesion the head is held back, in order to throw the centre of gravity farther backward, and thus necessitate less muscular action on the part of the extensors. When the head is brought forward it is apt to fall upon the chest, and the patient then experiences difficulty in bringing it back into the vertical position. If the anterior muscles of the neck are also paralyzed, the patient has no control over the movements of the head, and it wobbles from one side to the other with the movements of the trunk.

In advanced stages of the disease the patient is rendered absolutely helpless. He may be entirely unable to move a single part of the body, with the exception of the face and tongue. As a general thing, however, he is carried off by some intercurrent affection before this stage of utter helplessness is reached.

From the very beginning of the disease, fibrillary * contractions of the muscles are an important symptom in the majority of cases, although they are not pathognomonic. In some cases short, fluttering contractions of fibres in different parts of the affected muscles are seen almost constantly, coming on without any apparent cause. In other cases they are not visible, except after irritation of the parts, as, for example, after exposure of the integument to the air, brisk tapping of the muscles with the finger, faradization of the muscles, etc. When the atrophy of the parts is complete the fibrillary contractions cease. The contractions are too feeble to cause movement of the parts into which the muscles are inserted, except in the case of the small muscles of the hand. Here slight movements of the fingers are sometimes produced. The contractions are sometimes observed in parts which are apparently healthy, but they then constitute an indication of approaching disease in the muscle in question. In not a few cases, however, these contractions are unnoticed during the entire course of the ailment.

The mechanical excitability of the parts is sometimes greatly exaggerated, so that a slight tap may produce contraction, not alone of the muscle struck, but also of adjacent muscles. The changes in the electrical excitability of the muscles are very interesting and important from a diagnostic point of view. It has seemed to me that changes are present in all cases. At times the disease may make considerable progress before any other change is noticeable than simple diminution of irritability to both currents, corresponding to the amount of atrophy of the muscles. But in not a few instances we have observed decided changes at the very beginning of the disease. At the present time I have under my observation a case in which the disease has lasted only a few months, and the atrophy is confined to the small muscles of the right hand (thenar and hypothenar eminences, interossei). Nevertheless, the atrophic muscles present a distinct partial "degeneration reaction" (slowness of contraction, excess of An Cl C). It is often very difficult to detect the changes, because the degenerated fibres lie in the midst of healthy ones and the contraction of the latter may alone be evident. In addition, the increased excitability to the galvanic current found in complete De R (degeneration reaction) is usually absent. I have generally succeeded, however, in detecting the slowness of contraction of the atrophic fibres by using a mild current, which will produce a barely visible contraction of the healthy fibres. This phenomenon may also be made evident, even when the contraction appears of normal rapidity, by comparing the contractions with those produced in healthy parts. In some cases this is the only change noticeable. In others we also find predominance of An Cl C, or a tendency to tetanus during the passage of the current. When an exacerbation of the paralysis takes place very quickly, as sometimes happens, and is followed by rapid atrophy of the muscles, the latter may present all the changes of complete De R. Diplegic contractions have also been observed by a few writers. This term is applied to the following condition: When a small anode is placed in the mastoid fossa, and a broad cathode between the scapulæ, muscular contractions are observed in the arm opposite to the anode. These diplegic contractions are regarded as a reflex phenomenon, but possess no diagnostic importance, as they are also observed in other conditions.

The cutaneous and tendon reflexes are lost very early, even after comparatively slight atrophy of the muscles.

The integument over the atrophied limbs is usually cool to the touch, and pale. Trophic changes in the skin are rarely observed. Gowers refers to a case in which the skin of the face became thin and smooth, so that the iris could be seen through the closed eyelids. Pemphigus vesicles have been seen upon the palm of the hand in this disease. The skin and nails are occasionally thickened, and the latter may become brittle and fissured. A scaly condition of the skin and a tendency to ulceration have also been noticed. Enlargement and tenderness of the joints are rare phenomena; they are noticed particularly in the phalangeal joints, but have also been observed in the shoulders. I have seen a similar condition in the metatarsus during the early stages of the disease.

Excessive local diaphoresis has been reported in a few cases.

Among the rare phenomena noticed we may also mention the oculo-pupillary changes (contraction of one or both pupils, slow reaction to light), which are probably due to direct injury to the cilio-spinal centre in the cervical cord, and not to an affection of the sympathetic.

In the majority of advanced cases the temperature of the skin is lowered over the affected parts, but in rare cases there is distinct elevation of temperature—some-

* This term is a misnomer, since the contractions involve fibres or bundles of fibres; the term fascicular would be preferable.

times as much as five degrees—in the atrophied regions. Grasset has observed local elevation of temperature, associated with redness and sweating, confined to the palmar surface of the first phalanx.

In equally rare cases there is slight œdema of the hands and forearms, perhaps as the result of impairment in the circulation. These parts sometimes appear swollen from the increased development of subcutaneous fat.

Micturition and defecation remain normal throughout the entire course of the disease, unless the abdominal muscles are seriously wasted. In three cases Rosenthal found a diminution of kreatinin in the urine. Slight diminution in the amount of urea has also been noticed. Frommann reports large deposits of carbonate of lime, which he attributes to absorption from the atrophied muscles.

The disease always runs a slow, chronic course, and twenty or thirty years, or even more, may elapse before the fatal termination. In some the process spreads continuously, in the majority a remission occurs after a certain amount of progress has been made. This remission may last a variable period, from a few months to a number of years. Even a permanent arrest of the disease has been reported. In rare cases the process is attended with sudden exacerbations. The patient suddenly suffers from a considerable increase of paralysis in a certain limb, and this is followed in a few days by rapid atrophy of the paralyzed muscles.

In a not small proportion of cases the disease may become complicated at any stage by bulbar paralysis, or the latter may precede the former.

Death usually results from this latter complication, or from diseases of the respiratory organs aggravated by paralysis of the muscles of respiration; more rarely from intercurrent affections.

Pathological Anatomy.—The affected muscles are pale, and it may be difficult to distinguish any muscular structure in them. Under the microscope the changes are found to be confined almost exclusively to the muscular fibres. The capillaries of the interstitial connective tissue may be enlarged, the nuclei increased in number, and the fibrous tissue may present hyperplasia. Normal muscular fibres may be seen among others which are very materially altered. Some fibres simply appear to be narrowed. When this simple atrophy is far advanced, the hæmoglobin in the fibre may disappear; in other cases pigment may be deposited within the fibres as yellowish and brownish granules. In others the transverse striæ are less distinct, and the fibre is studded with minute granules of fat which in places have coalesced into larger or smaller globules. In advanced stages the entire fibre may be converted into a mass of fat globules. The longitudinal striæ sometimes become very much more distinct than the transverse striæ, giving the fibre the appearance as if it were split longitudinally.

An important feature is the extreme rarity of hypertrophy of the fibres. W. Mueller seems to have been the only one who observed, in addition to the presence of atrophied fibres, decided hypertrophy of other fibres. Fibres presenting very serious changes may be found alongside of others which are apparently normal.

Our knowledge of the pathological anatomy of this disease, in perfectly uncomplicated cases, is extremely meagre. The majority of autopsies refer to cases which were complicated with bulbar paralysis, but we hold that such cases are as decisive with regard to the pathology of the affection as the uncomplicated cases. As we shall see later on, the process in both affections differs only in regard to localization.

Struempell has described the post-mortem appearances in an uncomplicated case as follows: The spinal cord, as a whole, was narrow. Atrophy of the anterior horns and disappearance of the ganglion-cells in these parts in the cervical region were observed very distinctly in numerous preparations. The left lateral column was free. Slight atrophy of the cells existed in the lumbar region. In this case the atrophy was limited almost exclusively to the arms and shoulders, especially on the left side.

In Pierret-Troisier's case there was found degeneration of the ganglion-cells of the anterior horns, particularly on the right side; this horn was shrunken. The anterior nerve-roots were atrophied and contained numerous extremely fine nerve-fibres; some of the latter contained fat-granules. The white substance of the cord was normal.

In the large majority of cases, however, the spinal lesions were not confined exclusively to the anterior horns, and most of these cases present various symptoms which do not form part of the clinical history of pure spinal progressive muscular atrophy.

In a case in which, in addition to the usual symptoms of the disease, the patient suffered from severe paroxysms of pain in the lower limbs and violent muscular twitchings, Charcot and Gombault observed the following post-mortem appearances: There were profound alterations in the anterior horns of the cervical and dorsal cord (the atrophy had involved the upper limbs, neck, and back). In the lower part of the cervical enlargement there was almost complete disappearance of the ganglion-cells and of a great part of the nerve-fibres in the anterior horns. The dimensions of the anterior horns were not lessened to a notable extent, probably because there was such an enormous development of capillaries in this region. The lateral and posterior columns were intact throughout. There was sclerosis of the anterior root-zone in the cervical and dorsal regions. This sclerosis corresponded closely in degree with the lesion of the anterior horns, and was regarded by the authors as secondary to the latter. There was thickening and manifest inflammation of the pia mater at the emergence of the anterior roots. This was also observed over the remainder of the pia mater, but diminished posteriorly. There was a narrow zone of cortical sclerosis over the antero-lateral portion of the cord. The anterior nerve-roots of the cervical and dorsal regions were almost entirely destroyed.

Numerous cases have been reported in which sclerosis of the pyramid tracts was found in addition to the lesion of the anterior horns. These cases should be included under the heading of amyotrophic lateral sclerosis, and will be found discussed in the article on that subject in this volume.

Post-mortem examination has shown, however, that the intensity of the lateral sclerosis varies more or less in different cases, and that these variations correspond to differences in the severity of the spastic symptoms which are associated with those of progressive muscular atrophy.

In order to secure a better understanding of the subject, the question of diagnosis will not be discussed until we have described the clinical history of the myopathies.

Prognosis.—The outlook is always unfavorable so far as regards recovery, and if the disease becomes complicated with bulbar paralysis, it is always fatal. The most that can be hoped for is cessation of the advance of the atrophy, or perhaps slight improvement. If the disease does not attack the respiratory muscles life may be prolonged for many years, but, as a rule, the patient is finally reduced to a helpless condition.

Treatment.—The majority of authors recommend gentle exercise, but it has seemed to the writer that complete rest answers best in these cases. At all events, we feel quite sure that this is true with regard to the wasted muscles. The only exercise to which these muscles should be subjected is that secured by the use of the interrupted galvanic current, which may be applied directly to the parts. The current should be mild and the sittings of short duration.

The application of galvanism to the spine has also been recommended. This is done by placing both electrodes (large sponges) over the site of disease in the spinal cord, a mild uninterrupted current being applied for five or six minutes every day, or every other day. The sittings must be long continued, but even then we rarely obtain any decided benefit. Massage may also be employed, but should be discontinued if it is followed by disagreeable sensations in the wasted muscles. Arsenic and strychnine have been administered internally, but do

not seem to be of much benefit. Gowers states that he has obtained the best results from hypodermic injections of strychnine, beginning with gr. $\frac{1}{85}$ once a day and gradually increasing the dose to gr. $\frac{1}{40}$. But even this writer does not claim to have done more than check the progress of the disease.

GLOSSO-LABIO-LARYNGEAL PARALYSIS. — Synonym: Progressive bulbar paralysis. *Etiology.*—Hardly anything is known concerning the origin of this disease. It is much more rare than progressive muscular atrophy. It appears to be more frequent in the male than in the female sex. Among eight cases of which the writer has kept notes, five occurred in men, three in women. In three of the cases (two males, one female) the disease was complicated with progressive muscular atrophy. In one of the cases the affection began at the age of thirty-two years, in the others between forty and sixty years. It is rarely observed before the age of thirty-five years. Heredity seems to exert no influence in the development of the malady, and nothing whatever is known concerning other predisposing causes.

We also possess very meagre information concerning the exciting causes of the disease. A number of cases have been attributed to injury, excessive exertion of the implicated muscles (blowing on wind instruments), depressing mental emotions, colds, and constitutional syphilis. But the influence of any of these factors is very problematical.

Clinical History.—The disease generally begins without any prodromal symptoms, though the patients sometimes suffer from pains in the back of the neck and shoulders. As a rule, the first symptoms are those of slowly advancing paralysis and atrophy of the tongue. The patient begins to experience a certain degree of difficulty in articulation, especially of those consonants which are produced by the escape of air between the tip of the tongue and the upper incisors, or the anterior part of the hard palate (*d, t, l, n, s*). As the paralysis of the tongue increases, the difficulty in articulation increases *pari passu*, and finally speech becomes wholly unintelligible. When this stage is reached, the tongue usually lies as an inert mass upon the floor of the mouth, and sometimes cannot be moved voluntarily to the slightest extent. Fibrillary contractions in the organ are often noticed from the very beginning. Atrophy of the tongue keeps pace with the paralysis. On account of the unequal distribution of the atrophy, the surface of the organ presents depressions here and there. The organ is diminished in length as well as in its lateral dimensions. I have seen this so marked that the patient was no longer able to grasp the tip of the tongue and draw it forward. The paralysis of the tongue also interferes with mastication and deglutition. On account of the inability to perform lateral movements of the organ, the patient is unable to remove the food from between the teeth and cheeks with the tip of the tongue, and generally uses the finger for this purpose. The interference with the movements of the base of the tongue also causes difficulty in conveying the bolus of food into the pharynx.

The paralysis of the tongue has usually not advanced very far before the lips become affected. In some cases, indeed, both parts appear to be attacked almost simultaneously. This is first shown by interference with the articulation of those sounds whose production depends mainly on movement of the lips (*p, b, f, v, m, o, u*). At the same time there is difficulty in whistling, etc. If the finger is inserted between the lips and the patient is directed to contract the parts in order to compress the finger, it will be found that this is done with much less vigor than in the normal condition. The coincident atrophy of the lips usually becomes distinctly visible after a while, though this does not always happen. But the atrophy of the orbicularis oris can always be detected by grasping the lip between the thumb and index-finger, and thus determining its thickness. When the atrophy has made considerable progress, the mouth is kept half open, and the saliva is constantly dribbling. This is partly owing to the fact that the presence of the saliva no longer gives rise to the involuntary reflex movements of deglutition, by means of which it is conveyed into the œsophagus, and the secretion therefore makes its escape anteriorly. Careful measurements, however, have shown that the quantity of saliva secreted in twenty-four hours is often much larger than normal. This has been attributed by some to irritation of the salivary centre in the medulla oblongata.

The muscles of the chin are usually attacked about the same time as the orbicularis oris, and the corresponding movements of the lower lip are lost in consequence. Other facial muscles are very rarely affected, those inserted into the mouth (buccinators, levatores labii) being involved more frequently than the upper facial muscles. In rare instances, however, all the external facial muscles are paralyzed, and the face then presents the appearances of double peripheral facial paralysis.

The affection of the facial muscles gives rise to a peculiar change in the physiognomy. On account of the

FIG. 3647.—Case of Bulbar Paralysis Complicated with Progressive Muscular Atrophy.

unopposed action of the muscles inserted into the angles of the mouth and the upper lip, the latter is elevated and the mouth made wider. At the same time the naso-labial folds are constantly deepened. The lower lip, on the other hand, droops from its own weight. As a result, the patient constantly has a mournful expression of the lower half of the face, and this is heightened during laughter by the contrast between it and the upper part of the face, which retains its mobility. (Fig. 3647.)

Shortly after the development of the affection in the tongue and lips, the symptoms of paralysis of the pharynx and larynx begin and slowly progress. The muscles of the soft palate become paretic and the pillars of the fauces hang lower than normal. The posterior nares can no longer be closed perfectly during deglutition, and fluids are apt to regurgitate through the nose. For the same reason air escapes through the nose when the patient speaks, and speech assumes a nasal character. This also increases the difficulty in the articulation of labials, because a sufficiently strong current of air cannot be sent through the mouth to produce vibration of the lips. In the earlier stages of the affection this can be remedied to a certain extent by closing the nostrils, so that the entire current of air is forced to pass through the mouth. The paralysis of the pharyngeal constrictors increases still further the difficulty in deglutition. The

interference is first noticed with regard to solid food, so that the patient is compelled to confine himself to semi-solid, and then to purely fluid, articles of diet.

The laryngeal muscles are usually the last to be affected. The constrictors of the glottis are first attacked. The consequent inability to close the glottis permits the entrance of particles of food into the trachea and bronchi, and this may be followed by lobular (foreign body) pneumonia. At the same time the inability to close the glottis necessarily prevents vigorous cough, and may thus prove a very serious matter in the course of otherwise mild diseases of the lungs or bronchi. The muscles moving the vocal cords may also be attacked in comparatively rare cases ; this condition may be recognized during life with the aid of the laryngoscope. In such patients the voice becomes feeble and hoarse, and, finally, complete aphonia may result, although this is exceedingly rare.

The dangers arising from the paralysis of the pharyngeal and laryngeal muscles are increased still more by the fact that there is very often an early impairment of reflex action after stimulation of the mucous membrane. Krishaber has reported two cases in which this symptom was a premonitory manifestation of the disease.

In rare cases other nerve-tracts are also attacked. This is seen most frequently in the muscles of mastication (motor root of the fifth nerve). The masseters and temporals then undergo atrophy, and mastication is still further interfered with. The atrophy of the temporals is visible to the naked eye, and that of the masseters may be felt by grasping the muscle between two fingers inserted in the mouth.

Paralysis of the ocular muscles has also been noticed in rare cases, and may result in strabismus or ptosis. As a matter of course, the atrophy of the ocular muscles can only be inferred from their loss of function.

The electrical reactions of the paralyzed muscles are obtained with difficulty. The hypoglossal nerve is best reached by applying one electrode to the back of the neck, the other (small) electrode above and behind the hyoid bone. It is usually preferable to apply the small electrode to the tongue itself—this should be protruded as far as possible—and direct application may also be made to the velum palati and pharyngeal constrictors. Few patients, however, would consent to the latter manipulation.

The electrical irritability of the muscles, according to many writers, is simply diminished, but direct electrization of the tongue and lips will usually show partial degeneration reaction. Sometimes the formula of reaction is unchanged, and there is merely delayed and prolonged muscular contraction. Even this change may be so slightly marked, that comparison with healthy individuals is necessary in order to detect the deviation from the normal rapidity of contraction. Diplegic contractions are sometimes obtained in this disease as in progressive muscular atrophy.

Sensation remains unaffected in the mucous membrane covering the paralyzed muscles. At the most there may be slight aberrations of the sense of taste, but this can be explained by the fact that the mouth is generally lined with thick, glairy saliva, and that the tongue is usually coated.

Headache is occasionally a prominent symptom. The pain is referred usually to the frontal or occipital regions. Severe pains are also experienced occasionally in the back of the neck, particularly in those cases which are complicated with progressive muscular atrophy.

The disease usually runs a slowly progressive course, and lasts from two to five years. In some cases quite sudden exacerbations are observed. Remissions are also possible. In a case under the writer's observation at present, the first symptoms appeared more than six years ago. Soon after the patient came under treatment (five years ago) the symptoms began to improve slightly, and have remained at a standstill for the last three years.

But such a course is entirely exceptional. The patients gradually grow weaker and weaker, and finally die of inanition, perhaps accelerated by "foreign-body pneumonia," resulting from the aspiration of food into the air-passages. In certain patients respiratory and circulatory symptoms are observed in the later stages of the disease. Without any apparent exciting cause, severe attacks of dyspnœa suddenly develop and may even prove rapidly fatal from suffocation. The causation of these attacks is obscure.

In other cases the pulse is excessively slow, or it may be so rapid that it can hardly be counted. The patient suffers often from palpitation of the heart. This symptom is undoubtedly due to the spread of the bulbar lesion to the nucleus of the pneumogastric. Syncope ensues, but usually disappears very quickly, to reappear sooner or later. The patient may pass safely through a large number of these attacks, but they are not infrequently the immediate cause of death.

Bulbar paralysis is often complicated by progressive muscular atrophy or amyotrophic lateral sclerosis. The symptoms of the former affection may either precede or follow those of the latter.

The intellect is usually unaffected throughout the entire course of the disease. But the patients generally recognize the hopelessness of their condition at an early period, and exhibit a tendency to weep on very slight or no provocation.

In the large majority of cases the muscles are attacked in a typical order—first the tongue, then the lips, finally the velum palati, and the pharyngeal and laryngeal muscles. In exceptional cases, however, this order is not maintained. Duchenne observed paralysis of the velum palati and lips prior to that of the tongue, and this sequence has been seen by others.

Pathological Anatomy.—In the majority of cases the medulla oblongata, the site of the disease, appears unchanged to the naked eye. In some cases, however, the organ appears somewhat smaller than normal, and presents peculiar depressions in the floor of the fourth ventricle. As a rule, macroscopic changes are noticeable in certain of the bulbar nerves, the hypoglossal, facial, pneumogastric, spinal accessory, sometimes the glosso-pharyngeal, in rare cases in the motor root of the fifth nerve and the abducens. The nerves in question are smaller than normal, and have a grayish, translucent look.

Under the microscope the changes are very pronounced. They may be confined exclusively to the nuclei of the nerves mentioned above and their intra-medullary nerve-tracts, or the white matter may also be implicated to a certain extent.

As we are led to expect from the clinical history of the disease, the lesion is most marked in the nuclei of origin of the hypoglossal nerves. The ganglion-cells in this region present all stages of atrophic degeneration. Some have merely lost their prolongations and have become more rounded, and perhaps the nucleus is recognized with difficulty. Or, in addition, the protoplasm of the cell contains an unusual amount of brownish or yellowish pigment. In the most advanced stages the cell is merely represented by a shapeless mass of pigment, its original structure being entirely lost. Between these two extremes is found every possible gradation. The changes usually diminish in intensity from within outward.

Some observers have also described changes in the neuroglia and blood-vessels surrounding the ganglion-cells. The neuroglia may be increased in amount and present a more fibrillated structure than normal. In comparatively recent cases it sometimes contains compound granular corpuscles. The walls of the blood-vessels may be thickened, their nuclei increased, and the surrounding lymphatic spaces may contain an increased number of round cells.

Similar changes, though usually less pronounced, are found in the nuclei of the pneumogastric and spinal accessory nerves, the inferior nucleus of the facial, sometimes in the glosso-pharyngeus, trigeminus, and abducens. It is a peculiar and significant fact that the nucleus of the acoustic nerve always escapes, so far as I have been

Spinal Cord.

able to ascertain from a quite careful review of the literature of the subject.

In a large proportion of cases analogous lesions are found in the ganglion-cells of the anterior horns of the cervical cord.

But the lesion is not confined, in very many cases, to the ganglion-cells of the medulla. Déjerine has collected the reports of twenty-two cases of bulbar paralysis, and found that in the majority there was sclerosis or atrophic degeneration of the pyramid tracts. This is usually most marked in the medulla, and diminishes in intensity in an upward and downward direction. In two cases Déjerine found that the lesion extended into the cerebral peduncles, and was entirely similar in appearance and localization to the descending degeneration occurring after a lesion of the motor tract in the brain.

Under the microscope the affected nerves are found to contain an increased number of narrow fibres, and some fibres may even disappear completely, leaving merely the empty sheath. Granulo-fatty degeneration is also visible in some fibres. There is no notable change in the interstitial tissue.

The paralyzed muscles present the same appearances under the microscope as in cases of progressive muscular atrophy.

Diagnosis.—The diagnosis of chronic progressive bulbar paralysis is usually not a very difficult matter. The symptoms of acute bulbar paralysis resulting from hæmorrhage, thrombosis, or embolism of the medulla oblongata, are very similar to those of the chronic affection under consideration, but a mistake is prevented by the acuteness of the onset—usually as sudden as a stroke of apoplexy, though sometimes a few days may elapse before the bulbar symptoms are fully developed in cases of thrombosis. Even if we should be unable to obtain the clinical history of the disease, a mistake may be avoided from the fact that the paralysis, in acute bulbar lesions, is disproportionate to the muscular atrophy. In addition there is very often hemiplegia of motion, while sensory disturbances are also very apt to be present.

Tumors of the medulla, which are fortunately very rare, are excluded with greater difficulty, because they usually grow very slowly (the majority of these tumors are solitary tubercles). In the beginning the diagnosis may be almost impossible, but the tumor soon gives rise to compression of adjacent parts, and to general cerebral symptoms, and thus enables us to exclude bulbar paralysis. The symptoms of compression consist of paralyses of motion and sensation in the limbs, along the course of distribution of the bulbar nerves, of mellituria, etc. The general cerebral symptoms consist of headache, choked disk, vomiting, etc.

Pseudo-bulbar paralysis is the term applied to a bulbar complex of symptoms, which is due to lesions in other parts of the brain. It is usually the result of bilateral lesions of the internal capsule, corpus striatum, etc., but Kirchoff observed a case in which the bulbar symptoms resulted from embolism of the right middle cerebral artery, with secondary softening of the right corpus striatum, lenticular nucleus, and internal capsule. Barlow has also described a similar case, in which the bulbar symptoms followed embolic softening of the lower portion of the central and adjacent convolutions of one side. These cases can generally be excluded by the sudden onset of the symptoms, which are usually attended with cerebral disturbances, and by the absence of atrophy in the muscles or of changes in their electrical excitability.

Diplegia facialis (bilateral facial paralysis) could only be mistaken for bulbar paralysis on the most superficial examination. The patient, it is true, suffers from paralysis of the lips and disturbance of deglutition, on account of the food slipping between the cheeks and teeth; but the movements of the tongue and pharyngeal muscles are not interfered with, and the facial paralysis affects all the muscles of the face.

Oppenheim has reported a remarkable case of unavoidable error in diagnosis. The patient, twenty-nine years of age, first suffered from weakness in the hands and legs, then from difficulty in speaking and paresis of the lips, finally from difficulty in deglutition. There was also difficulty in opening and closing the mouth, and imperfect motion of the velum palati during phonation. Attacks of dyspnœa occurred subsequently, and speech became exquisitely bulbar in character. The tongue could be moved in all directions, but with difficulty. Electrical reactions were normal. On autopsy, nothing was discovered in the muscles, nerves, or central nervous system.

It is difficult to say how a mistake could have been avoided in this remarkably obscure case. Perhaps the absence of changes in electrical excitability might have aroused suspicions.

Prognosis.—Bulbar paralysis is almost always fatal. A few cases have been reported in which very marked improvement or even recovery has been reported, but this mere fact casts a doubt upon the diagnosis. Even a standstill which lasts more than a few months is a rare event. We may mention, however, that the patient shown in Fig. 3647 has fully held her own for the last two years. The patient either dies slowly from inanition, or death may occur suddenly from one of the accidents described in the section on Clinical History.

Treatment.—In a disease of this nature our therapeutic resources are utterly useless. Chief attention should be paid to the prevention of inanition, fluid food being administered through the œsophageal sound as soon as the disease has advanced to such a stage that there is danger of the entrance of food into the larynx and trachea.

Galvanization has been recommended in the form of stabile transverse currents through the medulla, one electrode being placed on each mastoid process, or movements of deglutition are produced by placing the anode on the back of the neck, and the cathode (with interrupting handle) on the side of the larynx.

Strychnine, iodide of potassium, and nitrate of silver have been recommended, but no good results are ever obtained from any method of treatment.

Pseudo-hypertrophic Paralysis. — *Etiology.* — In very many cases this disease has an hereditary basis. It often appears in brothers and sisters at about the same time in life. Meryon described eight cases in one family, Gowers four in one family. The writer has seen four (sisters) attacked in one family, two (brothers) in another. The hereditary influence is always transmitted by the mother, despite the fact that the disease generally attacks the male sex.

Age is another powerful predisposing factor, the disease almost always beginning during childhood. It is generally observed between the ages of two and five years, and is often noticed as soon as the child begins to walk. In rare cases, adult life is reached before the disease manifests itself. Among 100 cases collected by Seidel, 94 began before the end of the fifteenth year.

Sex also exerts a potent influence, boys being attacked much more frequently than girls. Among 220 cases collected by Gowers, 190 occurred in boys, 30 in girls.

Hardly anything is known concerning the exciting causes. A few cases have been found to develop after acute infectious diseases, exposure to wet and cold, and injury, but it is difficult to determine whether there is any real connection between the two series of events.

Clinical History.—The first indication of the disease is very often the tardiness with which the child begins to walk. This ability is acquired very slowly, and the child is soon tired by the exertion. If he has learned to walk before the onset of the disease, it is found that his gait loses in freedom and vigor, he becomes unable to run with ease, or to go up and down a flight of stairs, and finally even walking is attended with difficulty. At the same time the lower limbs begin to grow larger. The apparent hypertrophy may begin simultaneously in both calves, or it may first attack one, later the other. From the calves the pseudo-hypertrophy usually extends to the thighs (chiefly the anterior muscles) and the glutei. The lumbar muscles are very often the next to be attacked, or they may appear to be feeble from the start. Coincident with the enlargement of the various muscles is dim-

inution in their power. The enlargement often spreads to the muscles of the upper limbs, though these are more often wasted, and present a striking contrast to the excessive proportions of the lower limbs. The shoulder muscles are very often affected, particularly the deltoids. The muscles of the arm may be enlarged, but are also often wasted; those of the forearm usually escape for a very long time. The small muscles of the hand are hardly ever attacked.

The face is also involved in rare cases. The masseters may be enlarged, and the same condition has been observed in the tongue.

The enlarged, as well as the atrophied, muscles suffer diminution of power, and this gives rise to characteristic symptoms.

FIG. 3648.—Pseudo-hypertrophic Paralysis.

Until recently it was supposed that fibrillary contractions in the affected muscles never occur in this disease, but, as we shall see later on, there are some exceptions to this rule. This is also true of the degeneration reaction. As a rule, however, there is merely diminution of faradic and galvanic contractility. Sensation remains undisturbed throughout the disease.

After it has lasted a variable length of time, wasting appears in all of the hypertrophied muscles. The disease is slowly progressive, and death generally results from pulmonary affections, the gravity of which is increased by the muscular weakness, or from some other intercurrent disease.

We will now give a more detailed description of the individual symptoms.

Enlargement of the calves is usually the first symptom noticed, though sometimes the awkwardness and clumsiness of gait first attract attention. On the other hand, the size of the gastrocnemii may remain unchanged for a considerable time, despite the steady advance of the anatomical changes in the muscles. The enlargement of the calves is sometimes extremely great, and they may even attain a size of fifteen or sixteen inches in a boy ten years of age. The power of these muscles usually diminishes in inverse proportion to their increase in size, but their vigor sometimes remains approximately normal for quite a long time. True hypertrophy of these parts has been observed in rare cases.

The anterior leg group of muscles is not often enlarged, but the loss of power is usually more marked than in the calf. As a result, contracture of the latter takes place, and the heel is constantly drawn up, so that the patient, while standing, cannot bring it to the floor, and it is difficult to bring the foot to a right angle with the leg by passive motion. The movements of flexion and extension of the foot are necessarily interfered with, and the patient separates the feet in walking to a greater extent than usual, in order to widen the base of support. The calf muscles may remain firm—indeed, they may even assume an almost stony hardness,—but they do not present the elastic resistance of normal muscle.

The muscles of the thighs, buttocks, and back are usually the next to be involved. In many cases the buttocks alone undergo hypertrophy, and there may then be a very striking contrast between the large calves and buttocks and the wasted thighs. The loss of power in these parts gives rise to very peculiar disturbances in the position of the body when the patient stands, walks, or rises from the recumbent position.

When the patient stands erect the heels are usually raised slightly—sometimes very markedly, as shown in Fig. 3648—from the floor, and the weight of the body is thrown farther forward upon the ball of the foot. In addition, the pelvis becomes flexed on the thighs, and this tends to throw the centre of gravity still farther forward. Hence the back is thrown backward in order to maintain a balance, and forms a very prominent curve in the lumbo-dorsal region (lordosis), so that a line dropped from the most prominent part of the dorsal spine often falls several inches behind the most projecting part of the sacrum. This peculiar deformity disappears, as a general thing, when the patient sits down, and is probably not due, as has been believed by the majority of writers, to paresis of the extensor muscles of the back. When the patient sits down the weight of the trunk can be felt to tilt the anterior superior spinous process of the pelvis upward, and, as this takes place, the lordosis disappears, the spine becoming straightened. It is much more probable, therefore, that the lordosis is due to the tilting forward of the pelvis on account of the weakness of its extensors, and not to the paresis of the extensors of the spine.

FIG. 3649.—Pseudo-hypertrophic Paralysis. Position assumed by the patient in attempting to rise from the floor.

Certain characteristic phenomena are also observed in the act of walking. When standing erect the patient assumes the position described above. Then, as the act of walking is begun, the pelvis is raised very high on the side of the swinging leg, in order to allow the drooping toes to clear the ground. At the same time the trunk is carried far over toward the active leg, in order to bring the centre of gravity within the ball of the foot, and thus an oscillation is produced which resembles the waddling gait of a duck. I am able, from observation in a number of cases, to confirm Ross' opinion, that this is the

result of contraction of the gluteus medius—this can be readily felt on applying the hand to the buttock during the act of walking—and not, as Duchenne and the majority of other writers have believed, of paralysis of this muscle. All the movements in walking are slow and deliberate, and the patient is often compelled, in advanced cases, to aid himself in maintaining his equilibrium by making balancing movements with the hands, like a rope-walker. As the disease progresses still further, locomotion becomes impossible, and the patient is confined to the bed or chair.

In rising from the floor to the erect position, the following peculiar manœuvres are adopted: The patient first rolls over on his hands and knees; then the body is brought into the position shown in Fig. 3649, this movement being effected in great part by extension of the arms, which raises the trunk from the ground, and thus allows the lower limbs to be brought, with comparatively little effort, into the partly flexed position. The patient next places the hands in succession above the knees (Fig. 3650), at the same time pushing back the thighs, thus straightening the lower limbs and elevating the trunk still further. The next movement is to place the hands

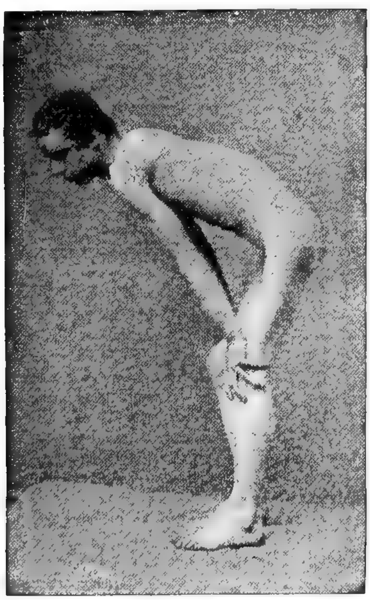

FIG. 3650.—Pseudo-hypertrophic Paralysis. Patient "climbing up his thighs" in the attempt to raise himself to the erect position.

on successively higher portions of the thighs ("climbing up the thighs") until the erect position is assumed. This peculiar method of assuming the erect position is not, however, pathognomonic of pseudo-hypertrophic paralysis, and I have often observed it in Pott's disease, whether in children or adults.

It is very rare to find hypertrophy so marked a feature in the disease of the upper limbs as in that of the lower, though cases have been described in which it was found in almost all the muscles of the body. In the upper part of the body the enlargement is limited much more often to certain portions. For example, the deltoids alone may be enlarged, or perhaps the deltoid and arm muscles on one or both sides. Hypertrophy has also been found in the muscles of the neck, back, and abdominal walls. The muscles of mastication (masseters and temporals) may be implicated in rare cases, and the tongue has been found a third larger than normal, so that deglutition and articulation were interfered with to a serious extent. According to Coste and Gioja, the latter condition was associated, in one of their cases, with the symptoms of hypertrophy of the heart. Gowers says that, next to the muscles of the calf, the infraspinatus is enlarged most frequently and markedly; the supraspinatus is also prominent at times.

But wasting is a much more prominent feature than enlargement in the affection of the upper limbs and trunk. This atrophy usually begins earliest and is most pronounced in the pectoralis major, particularly its lower half. The latissimus dorsi is also apt to be affected at an early period. According to Gowers, this is an important diagnostic sign and is sufficient to exclude the spinal form of muscular atrophy. Next, the scapular muscles undergo atrophy, and the process then creeps down the arms, the forearms being involved later and less frequently than the arms. The small muscles of the hand suffer in very few cases, and thus offer a striking contrast, in the majority of cases, to spinal progressive muscular atrophy. The muscles of the neck do not often undergo degeneration, though the process has been observed, in a few cases, in the sterno-mastoids. Even those muscles of the upper limbs which have undergone primary hypertrophy waste away after a comparatively short time. The diaphragm has, in a few cases, been found degenerated on post-mortem examination. When the atrophic process is far advanced in the upper limbs, the contrast with the enlarged lower limbs is especially striking. Paralysis of the muscles goes hand in hand with atrophy, and not only interferes with the specific movements of the upper limbs, but also with those movements of the lower limbs which had formerly been aided by the upper.

As the disease advances the patient finally becomes unable even to sit up, and is confined permanently to bed.

Fascicular contractions are hardly ever observed in this malady. In the rare cases in which they are present, they are not found throughout the entire course of the disease, and are not so apt to occur spontaneously, or with such frequency and vigor, as in spinal progressive muscular atrophy.

The electrical contractility of the muscles is usually diminished quantitatively, without any change in the mode of reaction. The diminution in the faradic and galvanic excitability, when the currents are applied directly to the muscles, seems to correspond with the diminution in the amount of normally acting muscular fibres. The electrical reactions through the nerves, however, are often stronger to both currents than when these are applied directly to the muscles. In rare cases partial degeneration reaction is observed in certain of the muscles. In Schultze's case, for example, distinct slow contractions were obtained in the left deltoid muscle with the galvanic current, and in addition the AnClC was more marked than the CaClC. Similar reactions were obtained in the first and fourth interossei and in the muscles of the thenar eminence. Other cases have also been reported in which the DeR was present. It must be remembered, however, that these changes in electrical excitability are very rare.

The patellar tendon reflex is usually diminished or lost at a comparatively early period, but this is merely the result of the loss of power in the quadriceps, and is not at all significant of any spinal affection.

Sensation may remain unaffected throughout the entire course of the disease. At first there are not infrequently vague pains in the lower limbs, and sometimes spasmodic twitchings in the calves, attended with painful sensations. After the disease has made some progress, the patient is apt to suffer from violent pains in the back, especially after he has remained in one position for a little while. The hypertrophied or atrophied muscles, especially the former, may be more or less tender on pressure.

The integument often presents a bluish-red, mottled appearance, particularly over the lower extremities. In these cases the skin is often cooler to the feel than normal. On the other hand, the integument of the hypertrophied calves sometimes has a higher temperature than that of the thighs or abdomen. Ord has observed an increased temperature of from one to two degrees.

Seidel has found that the increase in temperature produced by contraction of the degenerated gastrocnemius is from one to two degrees less than that resulting from contraction of the healthy muscles.

The functions of the bladder and rectum are usually intact, although obstinate constipation is not an infrequent symptom, especially if there is weakness of the abdominal muscles. The mental functions are commonly unaffected, but not a few patients are feeble-minded and even idiotic. Vigoroux reports a case which was complicated with Thomsen's disease.

The disease is slowly progressive, although there may be long intervals in which it is at a complete standstill. Even after the patient is confined helplessly to bed, he may linger for ten years or more. Death results generally from some pulmonary affection, such as bronchitis, phthisis, or pneumonia, which is aggravated by the feebleness of the respiratory muscles. In some cases even the intercostals become feeble, and this adds a new danger to any intercurrent lung affection. As a rule, death occurs within fifteen or twenty years from the inception of the disease, and few patients live beyond middle age.

Juvenile Progressive Muscular Atrophy.—This disease forms a clinical variety which, in typical cases, is quite distinct from other forms of progressive muscular atrophy of myopathic origin. It almost always begins before the age of twenty years, being most common in childhood. It is also often observed at puberty or during infancy. The hereditary element is the most striking feature in the etiology of this affection, and it occurs with comparative infrequency in isolated cases. Unlike pseudo-hypertrophic paralysis, it is not infrequent in girls.

Some writers believe that the pathological process in this disease is essentially distinct from that characteristic of pseudo-hypertrophic paralysis, but this position does not seem to be well established.

It begins generally in the shoulders and arms, sometimes in the lower limbs and back, and not infrequently in both localities at the same time. Throughout the disease atrophy of muscles constitutes the striking feature, but may also be attended with hypertrophy—sometimes true, sometimes false—in certain parts.

The atrophy, which is the first symptom, begins generally in the muscles of the scapula, shoulder-girdle, and arm proper; it then appears in the muscles of the back, buttocks, and thighs. The muscles below the elbow and knee are attacked late and with comparative infrequency. In the forearm, the supinator longus is most frequently affected, while the small muscles of the hand almost always remain normal, at least until a late stage of the disease. In the legs the peronei may be diseased at an early period, while the gastrocnemii long retain their normal bulk and power.

In certain parts, on the other hand, true or false hypertrophy of the muscles may be observed, the former appearing to constitute a compensatory process by which nature attempts to repair the damage done by the paralysis. These muscles include particularly the deltoids, gastrocnemii, supraspinatus and infraspinatus, the teres major and minor, triceps, and sartorius.

As in pseudo-hypertrophic paralysis, the pectoralis major, with the exception of the clavicular portion, and the latissimus dorsi are very constantly affected. The rhomboids, serratus magnus, biceps, brachialis anticus, supinator longus, and back muscles seem to be involved next in frequency to the pectoralis and latissimus dorsi.

When the disease attacks the lower limbs, it is found that the glutei, quadriceps, and anterior leg group, especially the tibialis anticus, are affected most constantly. The sartorius and gastrocnemii may escape for a long time, or may undergo true hypertrophy. Even in such cases, however, it is not uncommon to find that the hypertrophic muscles finally succumb to the atrophic process. A few cases have been reported in which the diaphragm and abdominal muscles also seemed to be involved.

Charcot has reported an interesting case in which the symptoms, so far as regards the distribution of the paralysis, corresponded exactly with Erb's juvenile form, but in which the bulk of the muscles did not undergo any change.

As in pseudo-hypertrophic paralysis, sensory disturbances remain absent, fibrillary contractions of the paralyzed muscles are observed very rarely, and there is simple diminution of electrical excitability to both currents, corresponding to the diminution in muscular bulk. The latter statement does not hold good in all cases, however, inasmuch as partial degeneration reaction may be present in certain muscles.

The disease may last from twenty to thirty years, or even longer, and its advance may alternate with periods during which the process seems to be kept in abeyance for years.

The following abstract of the history of a case (*vide* Figs. 3651, 3652, and 3653) now under the writer's observation, also furnishes an excellent illustration of the difficulties of diagnosis. For a number of years the patient had been regarded as a typical example of progressive muscular atrophy of spinal origin.

James M., forty-nine years of age. Family history negative. Patient had measles when ten years of age, typhoid fever at twenty-five; worked in iron works between the ages of eighteen and twenty-seven years. When twenty-seven years of age, after running two miles, he felt a lightness in the head and his sight left him for about ten seconds; he then vomited a good deal. He felt weak for a couple of days, but then returned to work. After this he would often feel stiff, sore, and weak in the back and legs after keeping still for a little while, but this would wear away after working. Two or three months later, he felt numbness in the tips of the fingers; this feeling would come and go. Weakness then developed in the right shoulder and arm, but the patient did not notice any wasting until two years had elapsed. Next the left arm grew weak, then the legs.

Fig. 3651.—Case of Juvenile Progressive Muscular Atrophy. (After a photograph taken in 1869.)

He entered Bellevue Hospital in 1869 (*vide* Fig. 3651, from a photograph taken at that time), and there gained sixty pounds in weight and grew somewhat stronger. At the end of a year he became slightly worse, and has grown rapidly worse in the last few years. The patient says the left calf has grown two and a half inches smaller in the last couple of years. He never saw any fibrillary contractions, but says that he has felt them during the last three or four years in various parts of the body, and also in the orbicularis palpebrarum.

Present Condition: Intelligence very good, nothing abnormal noticeable about the face or neck. Arms very much atrophied as compared with the shoulders and forearms. Right arm $8\frac{3}{4}$ inches, left arm $8\frac{3}{8}$ inches. Supination of left forearm is impeded as a result of old injury to the elbow. Right forearm $10\frac{5}{8}$ inches, left forearm $9\frac{3}{4}$ inches.

Right side: Hand, thenar and hypothenar eminences

Spinal Cord.

normal, flexion and extension of hand on forearm nearly, though not quite, normal; movements of fingers approximately normal. Flexion of the forearm on the arm is accomplished mainly by contraction of the supinator longus. Extremely feeble action of biceps and triceps. The deltoid is weak, but the arm can be raised to a horizontal position; trapezius well retained; no rhomboids can be seen or felt; the scapulæ cannot be approximated closer than seventeen and a half inches by voluntary effort. On the patient attempting to raise the arm, the lower angle of the scapula is separated more than three inches from the thorax. The latissimus dorsi appears to be lost. The supraspinatus seems normal, infraspinatus decidedly hypertrophied, but its power is somewhat diminished. Only a few fibres of the pectoralis can be felt.

Left side: Hand, slight depression over the dorsal interossei; diminished abduction and adduction of ring-finger; index-finger can be adducted fairly, but abduction is *nil*. Other movements of the fingers appear normal. The extensors of the wrist are much feebler than the flexors, and all the muscles of the arm are extremely wasted and feeble. The muscles of the shoulder and upper part of back are in about the same condition as those on the right side.

Fig. 3652. Front View of Same Patient. (After photograph taken in 1887.)

The deep muscles of the back can hardly be felt (there is considerable subcutaneous adipose tissue throughout the entire body). The glutei do not seem very much wasted, but have a doughy feel when relaxed. The patient can flex the thighs on the abdomen, but not with normal vigor. The quadriceps and hamstring muscles are very much atrophied on both sides. Right thigh, 17 inches; left thigh, 16½ inches. Adductors of thighs atrophied and flabby. Rotators seem moderately vigorous. Left anterior leg group very much wasted and soft, with corresponding diminution of power; right anterior leg group not much affected. Right calf muscles are a little soft, but not much wasted; those of the left leg are considerably wasted and paretic. Right leg, 13¾ inches; left leg, 12 inches. Slight patellar tendon reflex is present on both sides.

At the beginning of full inspiration there is slight sinking-in of the epigastrium, and the abdominal walls remain almost motionless. On forced expiration there is slight contraction of the abdominal muscles, most marked in the upper part of the recti abdominis.

While standing there is very marked lordosis, but this disappears in the sitting position and the back becomes straight. The lordosis is evidently owing to the tilting forward of the pelvis, thus necessitating a compensating curve in the dorsal spine to maintain the equilibrium.

The reaction of the wasted muscles to faradism is diminished throughout the body; this is also true, in the main, of the galvanic reactions, but certain muscles also present slight qualitative changes in galvanic excitability. In the triceps, for example, the muscular contraction is slow, and AnClC = CClC. This condition is also observed in the flexors of the left forearm.

The patient has the waddling gait of pseudo-hypertrophic paralysis, and rises from the sitting posture by "climbing up the thighs." Sensation is normal throughout the body; micturition and defecation are not interfered with. The disease has now lasted twenty-two years and, with the present slow rate of progress, the patient may live many years longer.

Infantile Progressive Muscular Atrophy.—Duchenne was the first to describe this affection, which he regarded as identical with spinal progressive muscular atrophy.

The disease usually begins about the age of five or six years, but it has also been known to begin in later youth, or even in adult life. As a rule, it first appears in the muscles of the face. The muscles attacked most constantly are the zygomatics and orbicularis oris. The wasting of these parts produces a peculiar change in the physiognomy. When the patient laughs the angles of the mouth are drawn upward instead of upward and outward, by the unopposed action of the levator labii superioris. At the same time the lips are kept slightly separated on account of the paralysis of the orbicularis oris, and the pronunciation of the labials is interfered with. The lower lip is pendulous and prominent, and often somewhat thickened. This latter symptom is not so constant, however, as has been supposed by the French writers. The face has a peculiar expression of mental hebetude, although intelligence is unaffected. In some cases the orbicularis palpebrarum, buccinator, and frontalis muscles also undergo atrophy. The tongue always remains unaffected, as do the muscles of mastication and those of the velum palati. Gowers has described a peculiar case which resembled the disease under consideration, and in which the ocular muscles were also paralyzed, but he was unprepared to make a positive diagnosis.

Fig. 3653.—Side View of Same Patient. (After photograph taken in 1887.)

The atrophy next attacks the shoulder and arm, and then spreads to the corresponding parts on the opposite side of the body. The shoulder-girdle and thoracic muscles are involved in turn, and finally the lower limbs, particularly the flexors of the thighs.

The forearms, with the exception of the supinator longus and the hands, are rarely attacked, though a few cases have been reported in which the muscles of the thenar and hypothenar eminences had entirely disappeared.

The supraspinatus, infraspinatus, and teres major and minor, are rarely attacked; the pectorals and latissimi dorsi are very commonly wasted.

The atrophy of the face may last five years, or even much longer, before any evidences of the spread of the disease become noticeable in the limbs or trunk.

In some cases the disease has begun in the arms or hands, and then spread, at a later period, to the face. This is especially apt to happen when the affection begins, as it rarely does, after the patient has arrived at manhood.

Hypertrophy of the muscles is never observed in connection with the atrophy, so far as I have been able to learn from the literature of the subject, with the exception of a case reported by Westphal, in which there was also pseudo-hypertrophic paralysis of the buttocks and thighs. As a rule, the electrical excitability of the affected muscles is simply diminished, but indications of partial DeR have also been reported in a few cases.

Heredity is the only known etiological factor in this rare disease. Duchenne reported, among others, two cases in a brother and sister; the father began to suffer from progressive muscular atrophy at the age of forty-eight years, but the face was not involved; the paternal grandfather had also suffered from some form of progressive muscular atrophy, which had advanced to such a stage as to render him entirely helpless. Westphal observed the disease in a woman who also suffered from paranoia, with periodical alternations between depression and exaltation and diabetes insipidus during the periods of exaltation.

In a considerable proportion of cases the disease does not run the typical course just described, and there are numerous transitions from one type to another. For example, Charcot has described a case in which the localization and course of the disease were similar to those of pseudo-hypertrophic paralysis, but the affected parts presented no increase in size. Again, Landouzy and Déjerine claim that the infantile form of progressive muscular atrophy is always attended by atrophy alone; but Westphal has described a case which was associated with marked pseudo-hypertrophy of the buttocks and thighs. In like manner I could show from the literature of the subject, did space permit, that there are transitions between all the varieties of myopathy, and it often depends upon personal bias whether the case is placed in one or the other category.

The disease may last very many years, and does not often prove directly fatal to life.

In concluding the clinical history of the various forms of progressive muscular atrophies, I will briefly refer to a peculiar variety, described by Charcot and Marie (Tooth has applied the term peroneal type to this affection), and which seems to occupy a position apart from the other forms. I will merely give a brief abstract of their paper (*Rev. de Méd.*, 1886, p. 97).

The disease always begins in the lower limbs, usually in the extensors of the great toe or the common extensor, or the peronei. This is the first noticeable symptom, though it is probable that the paralysis really begins in the intrinsic muscles of the foot, but escapes notice on account of the unimportance of these parts. All the muscles of the leg are gradually involved, the calves remaining unaffected longer than the other parts. Paralysis and atrophy go hand in hand, and finally become complete. The thighs continue normal for a certain length of time. The vastus internus seems the first to be attacked, the adductors are well preserved, and the flexors of the thigh are but little affected.

The hands become affected in from two to five years after the atrophy has begun in the legs. The change always appears first in the small muscles of the hands, and then extends to the forearms. The interossei are not always affected in a uniform manner. The extensors of the forearm usually suffer before the flexors; the pronators and supinators are attacked very late, if at all; the supinator longus is always normal. All other muscles remain intact.

Fibrillary contractions are very distinct, except in the last stage of atrophy. The direct muscular excitability is diminished in the affected parts, and this is true of the tendon reflexes.

In completely wasted muscles the electrical excitability is lost. In those less affected there is DeR; AnClC = or > CaClC, the contraction is slow, and faradic contractility is abolished. In slightly affected muscles there is simple diminished reaction to both currents.

The muscles do not undergo contracture; the integument of the affected parts presents well-marked bluish or reddish marbling. The subcutaneous adipose tissue may be increased. The temperature of the affected limbs is considerably diminished. These symptoms are less marked in the upper than in the lower limbs.

In four cases, sensation was undisturbed. In one of Eichhorst's cases there was hyperæsthesia of the dorsum of the foot; in another case there was diminished sensibility in the legs.

In one of Charcot's cases there was anæsthesia to touch and temperature, which became less marked in the upper part of the limb. There were also retardation and persistence of sensation, and the muscular sense was also slightly affected. This patient suffered from pains in the lower limbs.

Pains have also been observed in other cases, but do not seem to be an essential feature of the symptomatology. Cramps in the calves were noticed in almost every case. The other bodily functions were normal.

The disease generally begins in childhood or youth. Among 19 cases, 14 began before the age of twenty-two years. In one of Eichhorst's patients the disease was perhaps congenital; in another it began at the age of thirty-six years; in two of Wetherbee's patients, at thirty-nine years.

Pathological Anatomy.—A number of cases have been reported in which the most careful and competent examination failed to reveal the slightest evidences of change in the nerves or spinal cord. In a number of other cases slight lesions have been found in the spinal cord, but these were entirely disproportionate to the muscular disease, and were probably either secondary or mere coincidences.

"Granular disintegration" of various parts of the spinal cord has been observed a number of times by various English writers, but there is very little doubt that this lesion is an artefact, produced during the hardening of the tissues in alcohol.

Changes in the muscles, on the other hand, are found in all cases, but while the histological appearances are quite distinct from those described in spinal progressive muscular atrophy, those found in the various myopathies differ greatly from one another.

I will first give the results of my own examinations.

In a case of pseudo-hypertrophic paralysis, I observed the following: A large amount of adipose and fibrous tissue was situated between the muscular fibres. A few capillaries were found distended with blood, their walls thickened, and presenting nuclear proliferation. The vascular changes constituted a minor part of the morbid process. The muscular fibres were very markedly changed. They were very unequal in size, and few of them maintained the same dimensions throughout their entire length. A few fibres had a peculiar convoluted appearance, and a number branched dichotomously. In many the transverse striæ were indistinguishable, in others they were less distinct than the longitudinal striæ. Even in those fibres in which the transverse striæ were distinct, they did not seem to be as far removed from one another as in the normal condition. Some had a homogeneous swollen appearance (vitreous degeneration), and the sarcolemma had a jagged outline as if it were distended by its contents. In many places the muscle nuclei within the sarcolemma were increased in number, rounded, and only about a third the length of the normal nuclei. There was very great increase in the number of nuclei upon and around the sarcolemma.

In a case of Erb's juvenile atrophy the appearances were very similar to those just described, but not identical. The blood-vessels did not seem to be changed, but there were broad bands of fibrous tissue, containing numerous nuclei, and here and there a few clumps of adipose cells, running between the muscular fibres. The latter were very scanty and presented a striking contrast in size. The majority were very large, but a considerable proportion were much narrowed. Almost all had a vitreous appearance, but the striæ were distinct. In not a few there was transverse fissuring, and rarely longitudinal fissuring. No dichotomous fibres were seen, but there were a few convoluted ones. The nuclei within the sarcolemma were slightly increased.

In Schultze's case, which also resembled Erb's juvenile form, the increase of connective and adipose tissue between the muscular fibres was comparatively slight. Most of the latter were unchanged in size, but some were hypertrophied. There was increase of sarcolemma and muscle nuclei; the striæ were preserved; some of the hypertrophic fibres branched dichotomously. Schultze also observed a peculiar vacuolization of certain fibres. In some the vacuole included almost the whole width of the fibre, leaving only a small rim of muscle-tissue at the circumference. In others there were several vacuoles in one fibre, with a delicate meshwork of muscle-tissue between them.

In a case of atrophy with implication of the facial muscles (infantile progressive muscular atrophy), Westphal examined a piece of the left deltoid. He found simply hypertrophy of fibres (0.185–0.203 mm. wide, the normal width being 0.010–0.062 mm.), which otherwise looked normal; there was also some increase in the number of sarcolemma nuclei.

Gowers believes that the apparent hypertrophy is the result of "a vital contraction excited by the process of excision." This seems to be disproved by Schultze's case, in which the hypertrophy was observed on post-mortem examination, and not after excision in the living subject.

Hardly anything is known concerning the pathological anatomy of the peroneal type described in the section on clinical history. Charcot and Marie suggest that it is the result of peripheral neuritis, and in three cases interstitial neuritis was really found on autopsy. It must be admitted, however, that our knowledge of this affection is too imperfect to warrant us, for the present, in drawing any conclusions with regard to its pathology and pathological anatomy.

Pathology.—Extreme views are entertained with regard to the pathology of the affections under consideration. Some pathologists look upon them as being purely myopathic, others are inclined to regard them as purely central in origin. The majority of writers, however, look upon some of them as myopathic, others as myelopathic.

With regard to the pathology of bulbar paralysis, there can be very little doubt. It was long supposed, in accordance with the teachings of Duchenne, that this disease differs essentially from the progressive muscular atrophy usually regarded as spinal in origin, in the fact that the paralysis and atrophy of the muscles do not go hand in hand, the former being usually far advanced before the latter is appreciable. This statement is not in accordance with the facts, and the apparent discrepancy arises from the frequent difficulty of detecting atrophy in the affected parts. In more than one case I have remarked the failure of good observers to detect atrophy of the orbicularis oris in progressive bulbar paralysis, although this becomes evident at once as soon as the lips are grasped between the fingers, and the thickness of the muscular tissue is compared with that in healthy individuals.

In the tongue the atrophy is usually evident from a very early period in the disease. In all other respects this disease runs the same course as myelopathic progressive muscular atrophy, and the frequent combination of lateral sclerosis with one or both of the above-mentioned diseases points to the intimate relations between these three affections. Indeed, it seems very probable that they all are the result of one underlying cause, which, for some unknown reason, attacks only the motor system (one case of amyotrophic lateral sclerosis has been reported, in which not alone were the pyramid tracts involved in their entire course through the brain, but also the ganglion-cells of the motor cortical zone), and that, as the localization of the lesion takes place in one or the other locality, we shall find the symptoms of bulbar paralysis, progressive muscular atrophy, or amyotrophic lateral sclerosis.

The histological appearances of the paralyzed muscles also furnish a strong argument for the nervous origin of bulbar paralysis. Although our knowledge of the morbid anatomy of the muscles in the various muscular atrophies is still imperfect, nevertheless I think I am warranted in saying that the morbid appearances in those forms which are undoubtedly myopathic, are very different from those observed in paralyses of undoubted spinal origin, for example, acute anterior poliomyelitis; and also from those found in bulbar paralysis and the so-called spinal progressive muscular atrophy. The constant occurrence of the degeneration reaction is another important point in favor of the nervous origin of the disease. As we have seen in the section on clinical history, this is exceedingly rare in the various forms of myopathy, and has been observed hitherto only in lesions of the peripheral nerves or the anterior horns of the spinal cord.

The theory of the other school proves too much. If the spinal lesions, as is claimed, are secondary to the disease of the muscular system, there is no apparent reason why advanced stages of the latter should not always give rise to lesions of the cord. That this is not true is proven by numerous cases in which the central nervous system was found intact. This very fact seems to me to prove that the myopathic theory is insufficient for all cases.

The frequent combination of bulbar paralysis with progressive muscular atrophy points to the similarity of the two affections. Moreover, the clinical history is practically the same if we take into consideration the vital importance of the parts affected. In addition to the fact that the anterior horns of the spinal cord have been found diseased in pure cases of progressive muscular atrophy, we have the further fact that the symptoms of the disease are also observed in other affections of the spinal cord which extend to the anterior horns (deuteropathic).

We are therefore forced to the conclusion that bulbar paralysis and progressive muscular atrophy are due to primary lesions of the motor cells in the medulla oblongata and anterior horns of the spinal cord, respectively. The lesion in question is apparently of the nature of a simple atrophic degeneration, but some pathologists regard it as inflammatory in its nature. We possess insufficient data to decide this question, although I think the weight of evidence is in favor of the former view.

On the other hand, there are undoubted cases of primary myopathic disease, such as pseudo-hypertrophic paralysis and its allied affections, and it seems as if these latter diseases were more frequent than was formerly supposed. Many cases which were regarded as central in origin are now placed in the category of myopathic affections. But what the nature of the muscular lesion is I am unable to state. The theory of its inflammatory character does not seem to be in accordance with the pathological appearances. Nor is there, in my opinion, any satisfactory foundation for the theory that the changes in the muscular fibres are the result of compression, due to primary increase of the interstitial connective and adipose tissue. We may merely beg the question by saying that the disease is the result of a trophic disturbance in the muscular substance itself, resulting from a congenital or acquired anomaly of nutrition in the muscular system, and which probably gives rise secondarily to the changes which are observed in the interstitial tissue. We are also entirely in the dark with regard to the differences in the localization of the affection. It must be left to future investigations to decide whether these variations are the result of vital differences in etiology, or whether they are different forms of one disease. The prevailing opinion, at the present time, is very decidedly toward this latter theory.

The nature of the lesion in the "peroneal type" of muscular atrophy must be left for future investigations. We may say, however, that the strong hereditary element and the clinical history seem to indicate a peripheral, rather than a central, origin.

Diagnosis.—We will first consider the differential diagnosis of spinal progressive muscular atrophy from atrophy of myopathic origin.

The occurrence of fibrillary contractions is an impor-

tant sign. This symptom is quite constant in myelopathic atrophies, and until very recently it was supposed never to occur in the myopathic affections. We now know, however, that it is observed in rare cases of the latter. In myopathies, however, the symptom is not a prominent one, and does not appear to be of long duration.

The electrical reactions of the paralyzed muscles furnish another differential sign. As a rule, complete or partial (usually the latter) degeneration reaction is observed in myelopathic atrophy, even at an early stage of the disease. As we have pointed out in the remarks on symptomatology, this symptom may be elicited with difficulty when the healthy fibres in a muscle predominate over the atrophic ones; and if the latter are very scanty in proportion to the others, even the most careful examination may not disclose any change. In myopathic atrophies, on the other hand, simple diminution of excitability to both currents is the almost invariable rule, although recent observations have shown that partial degeneration reaction is present in some cases.

As a general thing, the diagnosis can be made from the manner in which the disease spreads from one part of the body to the other. Myelopathic progressive muscular atrophy begins almost invariably in the small muscles of the hand or in the shoulders, and then spreads to the muscles of the arms and trunk. In the myopathies, the small muscles of the hand are hardly ever attacked, even after the disease has lasted a long time and made great advances in other parts of the body. Furthermore, spinal progressive muscular atrophy usually attacks one muscle after another in such a way that we can follow its course, while the myopathic forms attack whole groups of muscles at apparently the same time. For example, the former disease will attack one interosseous muscle after another, then successive muscles of the thenar and hypothenar eminences, next the muscles of the arms, etc. But in the myopathic forms, for example in pseudo-hypertrophic paralysis, the patient will be found suffering, at the beginning of the disease, from weakness of almost all the muscles of the lower limbs and back, though some are affected more severely than others.

Heredity as an etiological factor is found almost exclusively in the myopathies, so that the occurrence of muscular wasting in more than one member of the same family is a strong argument in favor of its myopathic origin. The latter diagnosis is favored in an equal measure by the occurrence of the disease in childhood or youth.

Finally, the microscopical examination of excised portions of the affected muscles may throw some light on the diagnosis. In wasting of central origin, the muscle usually presents, at least for a long time, the evidences of simple degenerative atrophy; in myopathies hypertrophy of fibres is found in almost all cases, the transverse and longitudinal striation is usually quite well preserved, and interstitial changes are found at an early period.

In conclusion, it may be said that, while a careful examination of all the facts will generally enable us to decide between the muscular or central origin of the disease, in some the doubts can only be dissipated by post-mortem examination.

A few words with regard to the differentiation of spinal progressive muscular atrophy from other diseases of the nervous system.

At the onset of the malady the diagnosis of lead palsy is sometimes excluded with difficulty. The latter may begin apparently in the interossei and, in exceptional cases, the muscles of the thenar and hypothenar eminences undergo early atrophy. As a rule, however, the supinator longus escapes on the extensor side of the forearm, and the flexors remain normal, or approximately so. But if we remember that the wasting of lead palsy may also extend to the muscles of the arm and shoulder—indeed, sometimes to the lower limbs—and that DeR is present, it is evident that mistakes may arise. A case is at present under the writer's observation in which the interossei, thenar, and hypothenar eminences were first attacked, and for some time it was regarded as probably a case of progressive muscular atrophy. The patient has no blue line on the gums, no mode in which lead could have entered the system can be discovered, and chemical examination of the urine for lead was attended with negative results. The diagnosis of lead palsy was made on account of the previous occurrence of abdominal colic (without any ascertainable cause), the paralysis of the extensors without implication of the flexors, the complete DeR at an early period, and the comparative rapidity of improvement under treatment. In this case, as in a number of other undoubted cases of lead palsy, the supinator longus is also paretic, though not to such a marked degree as the extensors.

Deuteropathic progressive muscular atrophy, *i.e.*, that form of disease in which the atrophy results from the extension of a lesion in other parts of the spinal cord to the anterior gray columns, is distinguished from the protopathic variety by the presence of the symptoms of the primary disease (pains, anæsthesia, occurrence of paralysis before the development of atrophy, interference with the functions of the bladder and rectum, etc.).

After the diagnosis of myopathy has been made, the special variety is recognized by the localization of the wasting and hypertrophy of the muscles, and the course of the disease as described in the section on clinical history. A large number of cases, however, constitute transitions between the different types there mentioned, and cannot be definitely relegated to any special class.

Prognosis.—Complete restoration of parts which have undergone wasting or hypertrophy never seems to occur. In all cases, the chance that the disease will not shorten life is so much greater, the later the period at which the disease begins. When this takes place in adult life, the patient may live to an advanced age, unless carried off by an intercurrent disease. It must always be remembered, however, that diseases of the respiratory organs are a special source of danger in myopathies, on account of the frequent implication of the respiratory and abdominal muscles.

In pseudo-hypertrophic paralysis the lease of life is usually shorter than in the other varieties, but even here the disease may come to an apparent standstill for years. More rapid progress is often made after the patient is permanently confined to bed.

Treatment. — Pseudo-hypertrophic paralysis does not seem to be influenced by treatment. Massage and electricity have been recommended. Benedikt claims to have cured five cases by galvanization of the sympathetic, but his statements should be received with a great deal of caution. Uhde and Gowers have derived benefit from cutting the tendo Achillis when walking is prevented by contracture of the calf muscles. Duchenne reports two cases in which the disease was arrested by prolonged faradization of the muscles.

Better results seem to have been obtained by faradization and galvanization of the muscles in the other forms of myopathy, notably in Erb's juvenile form.

Leopold Putzel.

SPINAL CORD DISEASES: SPINAL HEMIPLEGIA.

Synonym: Brown-Séquard's Spinal Paralysis.—Spinal hemiplegia is the name, not of a disease, but of a group of symptoms, produced by unilateral lesions of the cord. Such lesions are in part of traumatic origin, such as gunshot wounds, or wounds with sharp instruments, resulting in partial destruction or section of one-half of the cord, the injury being limited to that side; in part the result of disease, as compression of one-half of the cord by a tumor, or blood-clot, circumscribed sclerosis, etc. Similar manifestations have been produced by experimental hemi-section of the cord in animals, especially at the hands of Brown-Séquard. It was the latter who first drew a clear picture of spinal hemiplegia, based partly upon his experiments, partly upon the analysis of reported clinical cases. Both the clinical picture and the physiological conclusions drawn from it, though often looked upon with distrust, are now pretty generally accepted Yet, future modifications of the physiological views are

not improbable. This is more likely to be true of the paths of the sensory fibres, the study of which has always met with great difficulties, than of the motor fibres, whose course seems to be pretty definitely determined. Modifications are the more probable, because the lesions of the cord upon which physiological views are based—experiments on animals are not now referred to, because their results are not always directly applicable to man—have rarely the precision necessary for exact conclusions, and observations in different cases have been, to some extent, at variance with one another.

The most prominent symptom is motor paralysis of only the lower, or of both lower and upper extremities, according to the location of the lesion. It is on the side of the lesion, though there is also, at times, slight paresis of the other side. There is often a temporary vaso-motor paralysis on the side of the lesion, indicated by a rise of temperature of the paralyzed limb. There is at the same time sensory paralysis—anæsthesia—of the opposite side of the body, while there is heightened sensibility—hyperæsthesia—on the side of the lesion. But this is only true of certain kinds of sensibility—that to touch, pain, temperature, etc.—while the muscular sense is abolished on the side of the lesion.

The physiological deductions from these clinical data are as follows: The motor fibres run in the cord on the same side as are the muscles supplied by them. They cross to the other side in the medulla oblongata. The slight paresis sometimes found on the other side is perhaps due to a small number of the motor fibres decussating with those of the opposite side in their passage through the cord, or, perhaps, each cerebral hemisphere is, to a certain extent, related to both sides of the body.

The sensory fibres pertaining to muscular sense also run through the cord on the same side, while all the other sensory fibres, very soon after their entrance into the posterior roots, decussate with those of the other side and run to the brain in the opposite side of the cord. Brown-Séquard believes that there are different nerve-fibres for the different kinds of sensibility—touch, temperature, pain, etc.—and that they lie in different parts of the cord; for there may be loss of one kind of sensibility and not of others, or one may be affected to a greater extent than the others. If this be true, those of pain and temperature are most nearly related, for they are usually affected to about the same degree.

The symptoms thus far given are those of severance or destruction of the nerve-strands in the cord. But there may be further symptoms dependent on injury of nerve-cells in the cord, or of the nerve-roots, or due to secondary degenerations. Destruction of the large ganglion-cells causes muscular atrophy. This atrophy is found in the muscles innervated from the level of the lesion. Destruction of the anterior nerve-roots also causes muscular atrophy; destruction of the posterior roots, anæsthesia. The latter is always on the side of the lesion. Therefore, on the side of motor paralysis the hyperæsthesia is limited above by an anæsthetic border. Secondary degeneration of the lateral columns below the seat of lesion causes muscular rigidity, exaggerated tendon reflexes, etc., in the parts affected by motor paralysis.

In some instances temporary paralysis of the bladder and rectum was observed. Rarer occurrences were acute decubitus on the side of sensory, and inflammation of the knee-joint on the side of motor, paralysis. After disappearance of paralysis of the lower extremity ataxia has been observed, probably due to injury of the posterior column. *Philip Zenner.*

SPINAL CORD DISEASES: SPINAL IRRITATION.

INTRODUCTION AND DEFINITION.—Although the complex of symptoms described by older authors under the name of Spinal Irritation has no pathological anatomy beyond the very probable one assigned to it by Hammond, of anæmia of the posterior columns of the spinal cord, the affection is, nevertheless, of sufficient importance, and is frequently enough met with, to deserve to be retained in the more recent nosology of nervous diseases. It is an affection characterized by acute pain in the spinal region, always increased by pressure over the spinous processes, and is associated with various disturbances of sensibility along the course of the spinal nerves, arising from the affected region, and with certain visceral functional derangements; the motor nerves are also affected, but in a lesser degree.

Spinal irritation is most frequently found in women between the ages of fifteen and thirty-five years. These subjects frequently present symptoms of hysteria, but the affection is often enough observed independently of the latter malady, and is occasionally seen in men, so that its distinct identity cannot be seriously doubted by anyone with moderate experience.

ETIOLOGY.—Among the predisposing causes of spinal irritation, sex comes first in order. As already mentioned, women are peculiarly liable to this affection, and those who show greater tendency to hysteria are more frequently attacked, but at times even the most phlegmatic become victims to it, and men are not exempt. This disease is most frequently seen between the ages of fifteen and thirty-five years, and therefore young adult life would seem to predispose to it; but it occasionally occurs at a later period, and even in old age, and it has been observed, though rarely, in childhood. The hysterical temperament, even in those who have never had any distinct hysterical attacks, must be considered as an efficient predisposing cause. Also, heredity plays an important rôle, the disease being very often met with in members of a neurotic family. In a number of cases the disease cannot be traced to any special cause. Anything that weakens or excites the nervous system may act as an exciting cause; such are strong emotions, violent passions, grief, fright, care, love, anxiety, mental over-exertion, etc.; also violent bodily exercises, excessive watching or working at night, forced marches, strains, falls, or blows on the back, insufficient physical exercise, abuses in venery, onanism, excess in the use of alcohol or tobacco, frequent ungratified sexual desires, bad food, and exhausting diseases, such as typhoid, malarial, and scarlet fevers, dysentery, diphtheria, etc.

Formerly affections of peripheral organs were credited with bringing on the disease in a number of cases, but this is no longer thought of.

SYMPTOMS.—The development of the disease is usually gradual, the first symptom being a slight feeling of discomfort, scarcely amounting to pain, somewhere over the spine, more generally in the dorsal region and between the scapulæ. This is at first felt only after unusual fatigue or exertion, but very soon becomes constant and amounts to severe pain. This pain varies considerably in intensity at different times and in different patients, and it is described as a sharp, burning, boring, or lancinating pain; it is always increased by pressure on the spinous processes of the vertebræ; occasionally the skin in the region of the pain is very hyperæsthetic, and contact with the clothing even is insupportable; at other times the pain in the back is so slight as to escape the patient's attention, who complains only of the excentric symptoms to be presently mentioned, and the pain is excited only by pressure over the spine. The location of the pain varies much in different patients, and in the same patient at different times; its most usual seat is the dorsal region, between the shoulder-blades, and the next most common locations are in the back of the neck, and, less frequently, in the loins; occasionally it is felt over the whole spine. Hammond, and others after him, describe a deep-seated pain over the other vertebræ, which is increased by pressure or movements of the spine.

Besides this pain, and more noticeable to the patient, are a number of excentric symptoms, more or less referable to disturbances of sensibility and of the functions of the vegetative organs, but also affecting, though to a lesser extent, the motor apparatus. The symptoms vary according as the pain in the back affects different portions of the spine. When the cervical spine is complained of we have neuralgic pains, and various paræsthesiæ, such as tingling, formication, and a feeling of heat or cold in the neck, chest, and upper extremities; at times vertigo, headache, noises in the ear, disturbances

of vision, fulness and a sense of constriction across the forehead, and tenderness of the scalp, especially in the occipital region. In some cases distinct disturbances of the functions of the mind, sleeplessness, etc., also nausea, vomiting, hiccough, palpitation, and pain in the stomach, fibrillary twitchings or stiffness, clonic or tonic contractions, or more or less violent choreic movements of the muscles of the arms and neck, and occasionally loss of power in the upper extremities. These symptoms are, of course, only in part present in each case, and vary considerably in intensity in different cases.

When the dorsal portion of the spine is complained of we have, besides pain and tenderness in that region, intercostal neuralgia, infra-mammary pain, gastralgia, nausea and vomiting, dyspepsia, gastric flatulence and acidity, heartburn, palpitations, and attacks of syncope, and some slight disturbances in the sensibility or motility of the lower extremities.

When the lumbar portion is affected the symptoms are tenderness in the lumbar spine, neuralgic pains, with formication and other paræsthesiæ round the abdomen and down the lower extremities, cold feet, at times spasm of the neck of the bladder giving rise to retention or incontinence of urine, costiveness, and pain in the rectum, uterus, and ovaries; also at times weakness of the lower extremities, or contractures, spasms, or clonic movements in the same.

When the whole spine is affected we have more or less a combination of the above, the symptoms being the most prominent in those regions which are supplied by the nerves arising from the cord at the point of the greatest spinal tenderness.

The symptoms of spinal irritation are, as a rule, alleviated by rest in a horizontal position.

Course and Duration.—The course of the disease can be inferred, from what has been already said, to be very fluctuating, improvement and relapses alternating in quick succession without any apparent cause, the chief symptoms sometimes rapidly changing and affecting different regions of the spine and body. Its course is in some cases very acute, the disease developing rapidly and terminating in the same manner. In most cases, however, it runs a chronic course, developing slowly, and is equally as slow in improving, lasting months, or even years, under the most efficient management. Some patients suffer more or less all their lives from some form or other of the affection. As a rule, however, a cure may be promised as a result of proper medical and hygienic treatment.

The question, "Can the disease lead to some more dangerous spinal affection?" may with safety, I believe, be answered in the negative, if we take into account the views of the more recent authors, who certainly have had better opportunities to study the disease, and who have not confounded it, as older authorities occasionally did, with organic affections.

As to the true nature of the affection, nothing is positively known; numerous hypotheses have been advanced to explain it, but none is absolutely proven. Some authorities claim that it is due to hyperæmia of the cord, while others, with Hammond, and I believe with some reason, assert that it is due to anæmia of that organ.

Case I.—C. B——, white, female, aged thirty-one; has been married two years, has one child living, does not belong to a neurotic family, gives no history of hysteria or any other nervous disease. She is a housemaid, but is much above her class in education, and is quite refined in manners, and evidently has seen better days. About a year before her application to me for treatment, the initial symptoms of her affection began to show themselves. After a period of prolonged grief she began to be troubled with an uneasy, painful feeling in the spine, about the upper dorsal region, after every severe exertion; this feeling soon became continuous, and was increased whenever she was accidentally touched on her back at that part of the spine: she was always easy at night, or when lying down. With the increase in severity of the pain she was also troubled with attacks of breathlessness and palpitation, and had a constant sharp stitch in the infra-mammary region on the left side. Her appetite soon began to fail, and she was greatly troubled with nausea and occasional vomiting; her head, she said, was not quite right, and she was troubled with some dizziness; she felt weak in the legs, and had feelings as of ants crawling between the skin and flesh of the lower limbs. She remained pretty much in that condition, one day feeling badly and the other better, for about six months, when she was forced to relinquish work and went to consult a physician, who treated her several weeks for dyspepsia, but with no relief. She became almost bedridden at that time, and, after changing several medical advisers, sent for me in December, 1884. I found the patient in nearly the condition described, though very much weaker and considerably emaciated; she remained altogether indoors, getting up from bed two or three times during the day, and only for a few minutes at a time. She felt well only while in the supine posture; her only nourishment consisted of two or three cupfuls of milk and weak beef-tea. I had no difficulty in immediately recognizing in her affection spinal irritation. I prescribed first a little whiskey and milk-punch at frequent intervals, day and night; this she retained with comfort. I then ordered a more generous diet, and gave internally one-sixtieth grain of strychnine three times a day, progressively increasing the dose, and the compound syrup of hypophosphites; I also began electrical applications, using the galvanic battery, and applied ascending and descending currents to the spine for from five to ten minutes every day. In a month's time the patient was so much benefited that she was able to come to my office, and in a few weeks more I discharged her cured. I meet this patient at frequent intervals, and she has had no return of her affection.

Case II.—In the summer of 1883 I was called in consultation by Dr. Bemiss, to see one of his patients in Ward 18 of the Charity Hospital. A. R——, aged nineteen, white, male, born in New Orleans, had had malarial fever of an intermittent type for some weeks. When examined he had been free from fever for some days, but he complained of exquisite pain on pressure over the lower dorsal vertebræ, with great weakness, pain, and numbness in the lower extremities; he felt comparatively at ease when lying down, but could scarcely stand on his legs; he had no gastric trouble, but had some difficulty in voiding his urine and was costive.

The case was pronounced one of spinal irritation, and the patient, being put on progressively increasing doses of sulphate of strychnine, with a generous diet and free stimulation, made a rapid recovery.

In searching over the patient's history no tendency to neurotic affections could be detected, and the malarial fever was evidently the sole cause of the spinal irritation in his case.

Case III.—M. B——, white, female, aged twenty-six, who has had one child, is highly nervous, but has never had any hysterical attack; gives a history of spinal irritation affecting the upper dorsal region four years ago, lasting several months, and being followed by complete recovery. She was admitted to Charity Hospital medical service in the early part of 1886, where she remained several months; she was then transferred to the gynecological ward, and was operated on for lacerated cervix uteri with success, but with no improvement in her general condition. In October, 1886, she was transferred to my service, presenting the following symptoms: Great tenderness over the lumbar spine, great pain and tenderness in the lower part of the abdomen and the lower extremities, inability to stand from weakness of the legs, retention of urine of several months' duration from spasm of the sphincter of the bladder, amenorrhœa of four months' standing, and costiveness. The muscles of the paralyzed parts were stiffened but well nourished, and responded normally to irritation. Treatment for spinal irritation. The patient was discharged, cured, two months after admission.

Diagnosis.—Spinal irritation, when fully developed, with all its regular complex of symptoms, is not difficult to recognize. In forming a diagnosis the principal points

to be relied on are: The presence of pain in the back, developed or increased by pressure over the whole or part of the spine; excentric symptoms, affecting chiefly sensibility, but to a slighter extent the motility also, of parts of the body receiving their nerve-supply from the affected portion of the cord, and various visceral disturbances already mentioned; the changeable character of the symptoms and the fluctuations in the course of the disease; and finally, the want of proportion between the severity of the subjective and the mildness of the objective symptoms.

The diseases with which it is more likely to be confounded are: The earlier stage of myelitis and spinal meningitis; spinal hyperæmia, hysteria, and spinal neurasthenia.

In myelitis we have absence of hyperæsthesia and tenderness, except on deep pressure over the spine; severe paralysis of sensation and motion in the extremities, and complete visceral paralysis; painful contractures and spasms, the absence of the nervous condition found in spinal irritation, and generally a fatal termination.

Meningitis spinalis is more difficult of differentiation; stiffness and painful contraction of the muscles of the back, pain in the spine, increased by motion, but not affected by pressure, with absence of tenderness in the part, the presence of fever, late paralysis, etc., will, as a rule, however, be sufficient to enable us to establish the diagnosis of meningitis.

Hyperæmia of the cord is still more difficult to distinguish from spinal irritation; indeed, some authors claim, as stated above, that the symptoms of the latter disease are due to a congested condition of the spinal marrow. The general absence of tenderness or pain in the spinal region, and the fact that the symptoms are aggravated by the recumbent position on the back, are characteristics of importance in spinal hyperæmia, and will generally suffice to distinguish it from irritation.

Hammond proposes as a test between these affections the relief given in hyperæmia and organic spinal diseases by the administration of ergot, while spinal irritation is made worse by the drug; and, on the other hand, the marked improvement in the symptoms of the latter affection caused by the use of strychnine, and the aggravation of spinal hyperæmia and the other diseases by the exhibition of this drug.

The characteristic globus, general spasms, and other symptoms of hysteria will suffice to establish a diagnosis between this affection and spinal irritation, though it must be remembered that the two are frequently found associated.

Neurasthenia spinalis, though resembling the disease under consideration, will be recognized by the fact that it is usually found in the male sex, by the absence of extreme spinal tenderness, and by the general preponderance of motor symptoms over those referring to sensibility. The two diseases have, however, an undeniable general resemblance.

Angular curvature of the spine from vertebral caries is not likely to be confounded with spinal irritation, and its characteristic symptoms need not be referred to here.

PROGNOSIS.—The prognosis is in general favorable, the majority of cases being cured, and a large number of the others benefited by judicious treatment. In a minority of cases improvement is, however, very slow, and at times imperceptible, and in others relapses are very frequent. Death has never been known to be caused by this affection, but some of the patients are doomed to a tedious illness, lasting perhaps for years.

TREATMENT.—The main treatment in spinal irritation should be directed to the removal of the cause of the affection, and to the improvement of the tone of the general nervous system and of the spinal cord in particular. It will suffice for us to refer our readers to the causes already mentioned to see how best they may be removed. To obtain the second object, hygienic and medicinal means are to be employed, such as a generous diet with plenty of wine and other stimulants, passive and active exercise for short intervals in the open air, the keeping of the recumbent posture for the greater part of the time, etc. The judicious use of certain drugs presently to be mentioned, and of electricity, is also necessary.

Cupping and blood-letting are scarcely ever indicated; counter-irritation to the spine by means of blisters, tartar-emetic ointment, or iodine, is of great use; hot applications to the back, or the use of the ascending galvanic currents with the two poles on the spine, one above and the other below the tender part, are recommended by Hammond as of great service in diminishing the tenderness.

Of the drugs themselves strychnine, in progressively increasing doses, is very useful; the phosphide of zinc in one-tenth grain doses three times a day, phosphorus, and phosphoric acid, are also of service. Opium, the bromides, and chloral are sometimes indicated, and general faradization with central galvanization is also recommended. Mountain- and forest-air is to be advised. Cold-water baths have proved beneficial in some cases.

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P. E. Archinard.

SPINAL CORD DISEASES: TABES SPINALIS. This term is applied rather vaguely to all forms of spinal disease attended by slow wasting of the substance of the cord, but of the posterior column especially. I think it is better than "locomotor ataxia," which is the term in popular use, or "tabes dorsalis," which just now it is the fashion to apply to cases of locomotor ataxia when there are only a few or no motor disorders. "Locomotor ataxia" is simply a clinical appellation, and its symptoms are not necessarily due to posterior column disturbances, but to lemniscal lesions, alcoholic neuritis, or other conditions. There is still a condition which is denominated "ataxic paraplegia," which is, after all, a hybrid disease. Tabes spinalis may be said to be an affection confined for the most part to the posterior column of the spinal cord, and attended by abolition or impairment of centripetal transmission and the irritation of the posterior nerve-roots, with varying sensory derangements, abased or increased tendinous reflex activity, motor inco-ordination, optic-nerve atrophy, and frequently various evidences of derangements of the sympathetic nervous system.

Although Todd directed attention to a variety of symptoms which are now recognized as those of the disorder, it is to Romberg[1] that the credit belongs of first accurately describing the disease under the name of *tabes dorsalis*, and who presented an autopsy made by Froriep in which degeneration of the posterior parts of the cord was found. In 1868–73, Duchenne de Boulogne revived interest in the subject by an elaborate and advanced consideration of the subject, and about the same time Trousseau, Charcot, Pierret, and other writers in France, and Westphal in Germany, added much to the literature, especially of the morbid anatomy. In Charcot's early work he established the existence of trophic changes, both osseous and dermal, and very little has been since added to his description of the arthropathies.

In England Russel Reynolds was among the first to consider locomotor ataxia, objecting to the prefix "progressive," which had been applied by Duchenne, and latterly Buzzard and Gowers have written well and extensively. In 1870–75 American writers, including Hammond, Clymer, Seguin, and myself, described the affection and presented cases.

The disease is one of a chronic and progressive nature, and while there are rare exceptions to this rule—especially those of traumatic causation—the greater number run a prolonged course marked by three stages: 1, The

prodromal, or *pre-ataxic* of some authors ; 2, the *developed*, or *ataxic* ; 3, the *degenerative*, or *stage of decline*. There are irregular varieties, one of which is known as the *hereditary*, or family, in which the subjects are young children, and there is a family history ; and Obersteiner and others have considered an ascending form which eventually has a cerebral extension, and is expressed by symptoms of mental disorder. There is also a form described by Fournier as *sclérose cérébro-spinale postérieure*, which is so irregular as to lead me to divide all cases of the disease into the *syphilitic* and *non-syphilitic*, the former, as it will be seen later on, being largely in the majority.

ETIOLOGY.—It was the generally entertained belief, until within a few years, that locomotor ataxia was due in nearly all instances to sexual excesses, an impression which probably grew out of the fact that most of these patients were syphilitic, and many syphilitic patients were amorous free lances. The real nature of the syphilitic causation was lost sight of until ten or twelve years ago, when Erb and others brought forward most astonishing statistics. The conclusions of the first author are very extreme, and he holds that ninety per cent. of all patients have a history of specific disease. In Germany and elsewhere he has many supporters, but there are a few men of temperate diagnostic zeal who reduce the proportion of syphilitic cases. Seguin has been unable to find more than twenty per cent.*

My own experience leads me to the conclusion that there are two classes of cases which possess some common characteristics, but which are very dissimilar in some ways. In one of these syphilis plays an active part, in the other there is no veritable specific history ascertainable. If we group these cases together a very high percentage of syphilitic cases is to be found, but the ratio of the hybrid cases,† in which syphilis is undisputed, is great to those of regular type and conventional progress. Of this class it is probable that fully ninety per cent. are syphilitic. Of what may be called the fixed-type class, there is not more than twenty per cent., or even less, where a reliable history of syphilis is to be found.

LOCOMOTOR ATAXIA OF IRREGULAR TYPE (SYPHILITIC).	LOCOMOTOR ATAXIA OF REGULAR TYPE (RARELY SYPHILITIC).
Of rapid progress ; prodromal stage short ; ocular symptoms early and diversified ; tendon reflex usually returns and is exaggerated, or is exaggerated from injury ; mental symptoms marked ; optic neuritis ; choked disk ; ataxia irregular ; possible extension to "general paresis ;" anæsthesia often irregular. Arthropathies uncommon. The young subjects with local cranial paralysis complicated with ataxic symptoms are usually syphilitic.	Of slow progress ; first stage often long—ten or twelve years ; Argyle - Robertson symptom ; pains and absent reflexes almost only early ocular symptom ; slow white atrophy ; ataxia of slow origin and bilateral ; plantar anæsthesia usually well distributed ; mental defects rare ; arthropathies common. Rarely helped by iodide of potassium.

Buzzard calls attention to the error one may fall into by impulsively choosing syphilis as a cause, when the pains and early symptoms may have preceded the syphilis for some years. I have borne this in mind in the examination of every case, and can support his views most emphatically. So far as sexual excesses go, I believe that any method of cohabitation which implies repeated spinal shock and exhaustion, must invite the approach of disease, and it is probable that forced and frequent connection, especially when the pleasures of Bacchus and Venus are enjoyed simultaneously, may sometimes originate a spinal exhaustion which will soon terminate in sclerosis ; but this is rare. The exceedingly fanciful ideas in regard to these causes entertained by the Germans are sometimes very laughable and improbable, and one writer in Ziemssen gravely alludes to the perils of coition in the erect posture, while another finds that twelve of his cases were addicted to the habit of *coitus reservatus*, a method which in this country, I believe, is common only in the Oneida community.

Sudden exposure to damp and cold, for which the person is unprepared, is quite likely to cause the disease. As instances I may mention patients who fell overboard or who stood in wet places while shooting. One patient left his warm bed and descended into his yard to chase burglars, without taking the precaution of putting on shoes or slippers. Traumatic cases of the malady are by no means unusual, though the exact manner in which injury gives rise to the disease is a matter of doubt. In making this assertion I leave out of question the cases of actual local vertebral violence, and the production of spinal bone lesions, and possibly meningitis confined chiefly to the posterior part of the cord. Railway concussion has resulted in a manifestation of symptoms indicative of locomotor ataxia. It is not of these cases I speak, however, for the morbid expressions are usually diverse. The traumatic scleroses are those, strange to say, where the rapid appearance of symptoms of posterior column disturbance has followed fracture of one of the long bones. I have seen several such cases.

Hereditary cases are of a distinct type, and I am convinced are not purely localizable posterior sclerosis. I feel sure that the real cause of such congenital disease is often a syringo- or hydro-myelia, the cavity occupying the posterior half of the cord.

Tabes is rarely found in women, and I can recall but a dozen personal cases of several hundred I have seen during the past twenty years, and four of these were syphilitic subjects. But two of these patients were classical cases, and the symptoms were due to lesions limited to the posterior root-zones of the spinal cord. Of Eulenberg's 149 cases, 128 were males and 21 females. The experience of other authors is my own. As to age we find that, except in rare instances, the disease seldom attacks individuals under twenty. Leyden fixes the limit as between the twenty-fifth to forty-fifth years.

Of Eulenberg's cases, to which allusion has just been made, the ages of invasion were :

	Male.	Female.
Below 10	0	1
10 to 20	2	0
20 to 30	35	12
30 to 40	39	7
40 to 50	47	1
50 to 60	5	0
Over 60	0	0

SYMPTOMS.—The prodromal symptoms of tabes are vague and irregular, but, like the early indications of so many serious nervous diseases, are mostly sensory. For a long time the early advances of the malady may be disregarded by the patient or his friends, and the pain ascribed to several causes. Many ataxics are regarded in the beginning as hypochondriacs, even by competent medical men, and sometimes a careful examination will fail to reveal anything positive ; for while the two earliest positive indications—the Argyle-Robertson pupil and the absent tendon reflex—are to be determined in the majority of cases at a time when nothing else is manifested, there are many exceptional cases where the ocular symptom is not present, and where it is possible to evoke a patellar tendinous reflex by proper excitation. In the ordinary cases the patient complains at a very early period of fatigue and uneasiness in the lower extremities, and some persons have likened the sense of tingling and fatigue to that which follows a long walk. The muscles at the back of the thighs and legs are tired and sore, and the ankles and knees are "weak" and ache. Slight exertion produces discomfort, and after a while actual pain of a shifting character and some plantar formication. Mental feebleness is also manifested, sometimes the patient being depressed or peevish, and hypochondriacal. He is annoyed, morbidly conscious of the attitude of his friends, and fearful of some impending disaster. Appetite and flesh are often reduced, and the bowels become sluggish. Some of my patients have complained of headaches, and these have been dull, lasting for several hours, and with subsidence there has been a free action of the kidneys, with the elimination of a large quantity of clear urine. The vision is more or less impaired, and

* Buzzard, while admitting that his notes are imperfect, found that 25 of 53 cases had a syphilitic history. Of Fournier and Erb's 127 cases, 59.8 per cent. were syphilitic. The average percentage of five American authors was 41.4.

† Many of them cases of ataxic paraplegia.

Spinal Cord.

transient attacks of diplopia are annoying. The pupil undergoes a change in its susceptibility to light stimulation, which has been described by Argyle-Robertson. This consists in preservation of the ability of the eye to accommodate with, of course, normal contraction or dilatation, but a failure of pupillary response to light stimulation; and it has been found that, owing to the abolition of the skin pupillary reflex, no dilatation of the pupil follows the pinching of the neck, which is the case in the normal individual. This symptom is by no means constant, but is a very common and suggestive indication.

In many cases we find even the pre-ataxic stage of the malady marked by disappearance of the patellar tendon reflex. The absence of the *knee-jerk*, which was first described by Westphal, may be determined best by making the patient sit upon a high table or desk, so that his thighs are well supported and his legs hang loosely at right angles. Then a smart blow may be struck with a ruler or small percussion hammer just below the patella, or to one side over the fibular head. No movement of extension may follow, though a light tap over the vastus externus may evoke a well-marked contraction. The loss of the reflex may be unequal, that is, it may be present on one side and absent on the other. The other reflexes of the lower extremities are apt to be lost or diminished. Mitchell and a host of other observers have shown that the tendon reflex varies under different conditions. According to the latter, the action of the will in some other direction is apt to increase or conserve an apparently dormant reflex. This I have not been able to verify. This bluntness of the reflex is quite apt to be found in other places, and the reflex functions of the bladder are deranged, with a resulting difficulty in voiding urine.

Brissaud has devised a remarkably ingenious apparatus, by which the force of the knee-jerk may be exactly measured. In some cases, even at a very early stage, the tendinous reflex will be increased.

The Established Disease.—After a variable siege of premonitory symptoms we come to the pre-ataxic stage, which is often of long duration, and is characterized by the advent of pain, the loss of the tendinous reflex, the occurrence of pupillary changes. The pains of the ataxic are peculiar and almost unique. They are paroxysmal, fugitive, and intense—and, like those of the uncomplicated neuralgiæ, are greatly aggravated by change of barometric pressure. I have kept the records of one patient for several years, and in his case every easterly or southwesterly wind was preceded by an exacerbation of leg pain, which was as certain as the barometer. The pains more often have their seat in the thighs—usually the inner surface—but the tract of the great sciatic may be the chosen spot. With great suddenness a twinge of the most intense description will affect a spot not much larger than a quarter. Light at first, it increases in gravity, and, after a few minutes or a few hours, subsides and attacks some other spot. The quality of the pain has been likened to the tearing of flesh, the introduction of red-hot needles, and to various methods of torture—and the names *terebrating, needle, boring, stabbing*, have been applied, and *fulgurating, lightning*, with regard to their suddenness and violence. Sometimes the ankles or soles of the feet may be the seat of the painful spots, and I have often found the popliteal space to be the locality. In some cases the pains dart up and down the course of a nerve. There is a second variety, which is dull and in some respects resembles rheumatism; with this there is pain on movement, and considerable interparoxysmal soreness. The pains of posterior spinal sclerosis are by no means regular in their expression, for the patient may have them on one side or on both, and with varying degrees of severity. Subjective coldness of the limbs is common, and with the pain there is often cramping of the toes, and clonic contractures of the lower extremities, which is semi-involuntary. The patient does not seem to be free from suffering at any time that may be counted upon. The suffering is perhaps more extreme at night and more constant. In some cases the ataxic pains choose sites which are peculiar—the lightning pain attacking parts about the anus or running up the rectum, and with this there is a sense of perineal weight and some tenesmus. Testicular pains are rare, but are sometimes found, nevertheless, and clinicians have called attention to a horrible form of misery which consists in vaginal and vulvar pains, which are present in sclerosis in women—which is rare.

After a variable siege of pain lasting from a few months to even twenty years, we find other sensory manifestations, such as anæsthesia, hyperæsthesia, and paræsthesia, delayed conduction of sensation, and a loss of the muscular sense. As the disease is more often in the lumbar part of the cord than elsewhere, we naturally find most of the trouble below the waist. The anæsthesia may be uneven at first, and afterward general, or, if there be ascending degeneration, the fingers, hands, and arms are involved. A rare locality in cases in which the tabes invades the upper part of the cord is the episternal. In a few cases I have found a circumscribed area of anæsthetic skin in this situation. The common form is that known as "plantar," and much of the patient's unsteadiness is due to his inability to preserve his sense of contact. When his eyes are closed he readily falls, or when he washes his face he is apt to pitch forward. At night it is impossible to walk about the room without support of some kind. This anæsthesia of the soles may be unequal, so that perverted impressions are received. A feeling as if foreign bodies were in the shoes is a familiar complaint. Sometimes the sensation is compared by the patient to that which might be produced by sand or wool beneath the feet; again, as if the stocking was down at heel. A more grave, and correspondingly rare, form of anæsthesia is that of the vagina or rectum, and if the upper tracts be involved we find occasionally a faucial and buccal anæsthesia; but these phenomena do not belong to true cases of tabes spinalis.

Tactile sensation is decidedly blunted, and the perception of painful contact as well. Various experiments have been undertaken to determine the time of transmission of a pin thrust, for instance, in the lower extremities. In some cases the delay in perception is equal to a quarter of a minute. We may find that the painful impression is transferred and felt on the opposite side (allochryia), a curiosity described by Hammond; or it may be perceived several times after one irritation. In fact, all sorts of sensory anomalies are presented. The patient loses his ability to appreciate weight, and is unable to make comparisons.

In some cases the "constricting-band" symptom is presented, which, however, is more common in acute myelitis than in the disease under consideration. This girdle sensation, or paræsthesia, is often found at the same time with vesical atony. The superficial reflexes are exaggerated until the plantar anæsthesia is complete, though the knee-jerk be absent.

In the established disease the pains in the lower extremities are not those alone which annoy the patient. Intense, lancinating pains, called by the French *crises gastralgiques*, invade the trunk and much torture results. The pain is colicky, but much more violent than the familiar condition of suffering, and is fugitive. Sometimes it is attended by diarrhœa and by bloody discharges from the lower bowels, as well as vomiting. Cardiac pains like those of angina pectoris are features of tabes, but rare. In some examples of the disease the gastric crises take the place of the fulgurating pains in the lower extremities, and are a feature of the second stage; but in many cases the distal pains occur from time to time in the well-established malady.

As the central process of disease is confined chiefly to the dorsal and lumbar region of the cord, we find corresponding motor disturbances chiefly of the lower extremities. The patient begins to grow clumsy and awkward, not from a loss of power, but from an impaired ability to grasp the amount of muscular force he desires to use. When he stands with his feet approximated laterally, he sways to and fro, and often has to extend his arm, as a rope-walker would, to preserve his balance. When he walks there is rigidity, especially when descending a staircase or crossing a street, when he is in danger

of being run over. He comes down upon his heels, and these will be found worn. He spreads his feet, and the gait is swaying, the soles being "brought down with a slap," which gives his propulsion an appearance never to be mistaken. When he attempts to turn there is much tottering, and when he is embarrassed he is sometimes almost helpless. If the disease advances beyond this, defective co-ordination is seen when he attempts to perform acts requiring delicacy of adjustment—such as buttoning his clothing, winding his watch, writing, or using small instruments of any kind. He is unable to localize small spots.

The ocular symptoms of tabes are numerous. I have already alluded to the pupillary derangements, and, *en passant*, to the atrophy. There may be paralysis of the third nerve, usually single, but occasionally double. (See Charcot's case.) In fact, any of the muscles of the ball may be paralyzed, or all of them, giving rise to *ophthalmoplegia externa*.

A slow atrophy beginning in the early stage of the disease is a frequent symptom, and with it we find color-blindness and limitation of the field of vision. In one case of my own, a woman, there is very slight ataxia, absent reflex, light pains, a gradual loss of vision, and intense headache. In fact, this headache is very common with the neuritis of tabes.

The sexual organs undergo changes which consist usually of a tendency to priapism, nocturnal emission, and other evidences of irritability in the beginning, and a complete loss of power later on. The action of the bladder is impaired and the urine is passed slowly, and often falls with but little force from the end of the penis. It often contains a large quantity of the earthy phosphates or epithelial *débris*, and decomposes rapidly.

When the ataxic stage has existed for some time, the sympathetic nervous system seems to participate in the production of symptoms, and a variety of trophic changes occur which have elsewhere been described. (See Arthropathies.) Articular destruction, with luxation resulting from absorption of the heads of the long bones, especially of the lower extremities, is common. The alveolar processes undergo a change, so that the teeth become loose and drop out even when they are sound.

Various skin disorders, among them herpes and pemphigus, are found in old cases, and there may be dermal roughening or thickening. The nails, too, become affected, as Charcot has pointed out, and even exfoliation occurs. One evidence of a sympathetic complication in tabes is the acceleration of the pulse, which is permanent.

A grave trophic degeneration is that known as *perforating ulcer*, and is peculiar to tabes. Luckily it is a rare feature. An indolent ulcer forms usually upon the sole of the foot, which may lead to the necessity of amputation.

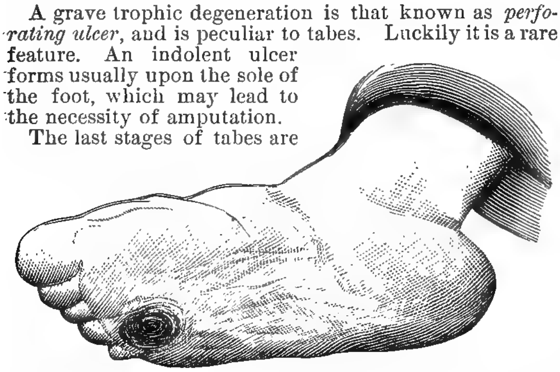

FIG. 3654.—Perforating Ulcer of the Foot in Tabes. (Gowers.)

The last stages of tabes are those attended by complete helplessness. The motor difficulties increase, the patient becomes thin and feeble, and the possible existence of repeated gastric crises, with vomiting and diarrhœa, leads to great exhaustion. Tuberculosis is not a rare result of such malnutrition. In some cases the arthropathies cripple the patient to such an extent that he passes the last years of his life in bed.

MORBID ANATOMY.—When the spinal cord is removed and examined, it is possible to find some external pinkish-gray discoloration at its posterior part. When a transverse section is made, this same opalescent appearance is detected. It is uneven both as to extent and situation, but more uniformly present in the lumbar region than elsewhere, though plaques of sclerosis are often found at higher levels or in the trunks of nerves. The finger passed over the posterior surface of the cord often reveals an induration. When a transverse section is made, discoloration may be detected by the naked eye between the two posterior cornua, which is somewhat translucent.

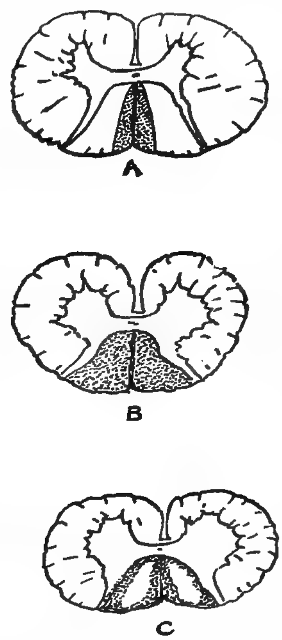

FIG. 3655.—Diagrammatic Representation of Common Areas of Sclerosis. A, Sclerosis of postero-median columns (Goll's column), most distinct in cervical region. B, Sclerosis of entire posterior columns. C, Sclerosis of parts of postero-median and postero-external columns, leaving central parts exempt.

The microscope reveals characteristic appearances in the lumbar, dorsal, and cervical portions of the cord, and the extent of the sclerosis depends largely upon the duration of the disease. We may find that the entire tract included by the commissure in front, the external roots laterally, and the posterior boundary of the cord, is the seat of a dense hardening, or we may appreciate various degrees of transformation. The most constant appearance, when the morbid process can be recognized at all, is adjacent to the posterior cornua, and next the column of Goll or postero-median columns. In ascending degeneration we find in the cervical and dorsal regions a density of tension in these columns, even when there is a more complete increase of neuroglia below; while the postero-external columns are longer exempt from involvement. The gravity of alteration is usually at first seen quite posteriorly, and even after extension the fibres of connective tissue radiating from the periphery are thicker than elsewhere. In some cases we find a tract of healthy tissue surrounded by a territory of sclerosis. In this form of sclerosis, as in others, the nerve-elements are more or less destroyed and their places are filled by thickened trabeculæ containing nuclei. The vessels found have thickened walls, and the outer coats are especially the seat of degeneration. Broken-down elements, amylaceous corpuscles, and the like are seen.

Numerous associated changes are often present—such as atrophy of the spinal nerves, meningeal thickening, and extensions of the morbid process into the lateral columns, and even the gray matter, are found. It is rare for any disappearance of the large nerve-cells of the anterior horns to take place, unless there is an associated atrophic condition. Sclerosis of the cranial nerves, or of the pons and posterior cerebral ganglia, are found in a small number of cases.

DIAGNOSIS.—Tabes spinalis is apt to be confounded with disease of the pons, alcoholic neuritis, cerebellar disease, cerebro-spinal sclerosis, and certain hysterical affections. In the early stages the pains are apt to be mistaken for those of rheumatism or neuralgia, but the peculiar nature of the symptoms—the non-involvement of the articulations and the association of the lost knee-jerk—are guides which should not be disregarded, and the same may be said of the Argyle-Robertson symptom. In some cases of disease of the pons there is inco-ordination, but the other associated symptoms—especially the pupillary contraction and absence of lightning pains—are suggestive. Alcoholic neuritis occasionally gives rise to

inco-ordination and ataxia. The pains in the lower extremities are, however, nearly always present, and there is tenderness of the plantar surfaces, glossy skin, and ordinarily atrophy. In many cases there is noticeable mental weakness. In cerebellar disease there is reeling and vertigo, and the walk is rather that of a drunken man. There is nystagmus, double neuritis, headache, and vomiting, none of which symptoms are ordinarily found in tabes. The tremor of cerebro-spinal sclerosis is not found in tabes; the mental dulness of the former is characteristic, and the speech disturbance is unknown in the spinal affection. The pains of tabes are never found in any of the forms of coarse disease I have mentioned.

PROGNOSIS.—Tabes spinalis is a progressive and fatal affection, and I do not know of a well-authenticated cure. In making this statement I exclude the syphilitic cases, but these even are only rarely cured by any treatment. The duration of the disease is exceedingly variable, and may extend from a few months to twenty years or more. The traumatic and some syphilitic cases are rapid in their development and unfavorable progress. The course of the disease is marked by periods of temporary improvement, and is retarded by proper therapeutical measures. I have effected an apparent improvement, in some cases, which has lasted several years, but the symptoms returned and the disease advanced. Optic-nerve atrophy is an exceedingly bad feature, and the development of the second or ataxic stage is an almost positive sign of a hopeless prognosis. Of the reported cures, doubtless these include examples of ataxia due to alcoholic neuritis, hysteria, or plantar anæsthesia of limited duration.

TREATMENT.—In specific cases our main reliance must rest upon heroic doses of the iodide of potassium—even several hundred grains daily may be given if the patient can bear such a quantity. The use of alkaline waters as a vehicle will enable him to take a much larger dose without gastric derangement than if water or other menstruums are used. Nitrate of silver and the tribasic phosphate sometimes improve the patient's condition, but arsenic is one of the best agents, and Gowers speaks highly of its efficacy in his hands. There is nothing, I am convinced, so important, not only in tabes, but all other forms of sclerosis, as *rest.* When this is possible we may greatly relieve, if not permanently improve, the patient, and a lady who consulted me after the development of the second stage, and who took to her bed and remained there for six months, has had very little trouble for several years, her gait being almost unaffected, and her pains entirely absent. I have known of very decided relief afforded in other cases by enforced rest. The gastric crises and occasional diarrhœa are best helped by morphine, and at such times rest is more important than at any other. Cod-liver oil and the hypophosphites are especially serviceable in the third stage.

The pains of the first stage are very difficult to relieve, except by morphine, which, strange to say, is usually well borne, and I have never seen the formation of the habit but twice. Sometimes the cases are helped by the salicylate of soda, antipyrin, or acetanilide (antifebrin), the latter by the mouth or subcutaneously. Various authors recommend the local application of chloroform, the tincture of aconite, or bisulphide of carbon by means of pledgets of cotton in wide-mouthed bottles. Cod-liver oil and the fats are necessary, and the discontinuance of tobacco, alcohol, except in an easily assimilable form, sexual intercourse, and exposure to extremes, is imperative. A warm winter climate should be selected—one of low elevation and withal dry is better than any other; and if it is possible to go to some sulphur bath, such as Sharon or Richfield, or the springs of Virginia in this country, or Aix-la-Chapelle, or those in the south of France, the patient will doubtless obtain much benefit. I would advise Southern California or Thomasville, Ga., or, in fact, any inland warm place. The Florida seacoast is not recommended, but such pine districts as that in the neighborhood of Seville, Fla., are suggested. I will say nothing about a variety of agents for the relief of special symptoms, vesical or trophic, for remedies will suggest themselves; but the physician is urged to carefully attend to the many little disturbances that may without care attain a dangerous magnitude.

It will be found that the patient's comfort can be greatly increased by the use of leaden insoles which are heaviest in front. *Allan McLane Hamilton.*

[1] A Manual of the Nervous Diseases of Man, New Sydenham Translations, vol. ii., p. 395. 1853.

SPINAL CORD DISEASES: TOXIC SPINAL PARALYSIS. Paralysis may be caused by various toxic agents, among the more important of which are lead, alcohol, arsenic, phosphorus, mercury, carbonic oxide, carbon sulphide, tobacco, camphor, ergot, and copaiba. The paralysis may occur in hemiplegic or paraplegic form, or may attack only groups of muscles, but in most instances its exact character has not been definitely determined.

The toxic paralysis most carefully studied is that due to lead-poisoning. It is most commonly found in the form of wristdrop—paralysis of the extensors of the fingers and wrists—but lead may cause far more extensive paralysis. Post-mortem examinations in such cases have revealed extensive degeneration of both muscles and nerves, and in a number of instances disease of the anterior cornua of the cord. The view now most commonly accepted is that the disease is primarily an anterior poliomyelitis—inflammation of the gray matter of the cord—and that the pathological changes in the muscles and nerves are secondary effects. Lead-paralysis would then be a spinal paralysis. But many still believe that it is mainly a peripheral paralysis, primarily in the nerves and muscles. Their opinion is based upon the extensive disease in the latter, and the ofttimes negative results of examination of the cord. The question cannot be considered as definitely answered.

One of the most common, if not most common, forms of toxic paralysis is that due to alcohol. Most post-mortem examinations of such cases in recent years have revealed the presence of multiple neuritis, with, in some instances, inflammatory changes in the cord at the same time. Alcohol-paralysis seems, then, in greater part to be a peripheral paralysis, due to neuritis.

Arsenical paralysis, especially in its clinical aspects, has been carefully studied in recent years. It sometimes has the appearance of peripheral paralysis, sometimes occurs in paraplegic form, and occasionally simulates locomotor ataxia, with ataxic gait, absence of patellar tendon reflexes, etc. It is not improbable that most of these paralyses are also due to neuritis. The same pathological basis may exist in the other forms of toxic paralysis, which have been less carefully studied. We may therefore be permitted to discontinue the discussion of the subject in this article, which is to treat only of spinal paralysis, particularly as it requires much further elucidation before anything can be stated definitely. But it is not improbable that toxic agents produce paralysis sometimes through the central nervous system, brain, or spinal cord, sometimes through the nerves; and the question is yet to be answered to what extent neuritis, especially multiple neuritis, so much spoken of recently, is due to conditions of the central nervous system.

Philip Zenner.

SPINAL CORD DISEASES: TUMORS OF THE CORD AND ITS MEMBRANES. Tumors within the vertebral canal, whether they spring from the cord itself or the meninges, produce symptoms mainly through irritation or destruction of nervous tissues. As they can rarely, if ever, be differentiated during life, it is convenient to treat of tumors of the cord and of the membranes at the same time.

The larger number of intraspinal tumors grow from the membranes, from the dura mater more frequently than from the pia mater; a smaller number originate in the cord, either in its substance or in the peri-ependymal tissue around the central canal. Some intraspinal growths spring from the bone or intervertebral substances, others from the tissues outside the vertebræ,

entering the canal through the intervertebral foramina. Circumscribed inflammatory exudations, from caries of the vertebræ, and hæmatoma, as they may produce similar manifestations, are sometimes included among intraspinal tumors.

The most common forms of tumors springing from the membranes are fibroma, sarcoma, and gumma; from the cord itself, glioma and tubercle. Among the tumors less frequently found in the cord or its membranes may be mentioned psammoma, lipoma, myxoma; tumors of a mixed type, myxo-sarcoma, glio-sarcoma; and parasitic growths, echinococcus, more rarely cysticercus. Neuromata, especially false neuromata, are found on the spinal roots, sometimes in large numbers. Enchondromata, sarcomata, and cancerous tumors sometimes spring from the bones or intervertebral tissues and compress the cord. Primary carcinoma is scarcely, or not at all, found in the cord or its membranes, but secondary deposits, especially after primary disease of the breast, are not very rare.

Tumors are most frequently single, but neuromata on the spinal roots are often multiple, and tubercles in the cord, though usually solitary, may occur in larger number, while secondary carcinomatous deposits are, perhaps, usually multiple.

The shape of intraspinal tumors is usually round, oval, or elongated. Their size is necessarily very limited, varying from that of a hemp-seed to the diameter of an inch or more. Tumors in the dura mater are usually larger than those in the pia mater. In the cord they rarely exceed one-half inch in transverse diameter, but sometimes have quite a considerable vertical extent, in some instances of glioma and myxo-glioma reaching the whole length of the cord.

Tumors may be found anteriorly, posteriorly, or laterally in the membranes, and therefore encroaching upon the cord, sometimes in one direction, sometimes in another. They may also be found in any part of the vertical extent of the cord or membranes, though tubercles are said to occur most frequently in the lumbar enlargement, and gliomata in the cervical region of the cord.

The tumors are usually distinctly circumscribed; sometimes—this is especially true of gliomata—they blend with the cord-substance.

The secondary changes in the nervous structure, produced by the compression or destructive action of the tumor, are of the greatest importance in the production of symptoms. Tumors growing from the membranes usually produce decided inflammatory or atrophic changes in the spinal roots and cord. The spinal roots are usually swollen and red, or in a state of inflammatory softening; in other instances they are degenerated and atrophied. Compression of the cord causes it to be flattened or narrowed at the point of pressure; sometimes produces an entire solution of continuity at that point, the extremities of the upper and lower segments being connected together by membranous tissue. The pathological changes in the cord-substance are sometimes only atrophy of the nervous elements, but usually there is a secondary myelitis, termed compression-myelitis. The cord is in a condition of white or red softening, with small extravasations of blood in the softened area, the microscope revealing granular cells and fragments of nervous elements. The inflammatory process is likely to extend some distance below the seat of compression, especially in the gray matter; and occasionally it extends a short distance above the point of compression. Degeneration of the white columns of the cord above and below the lesion, according to the Wallerian law of secondary degenerations, is usually found. A localized chronic meningitis in the neighborhood of the tumor, often resulting in an increase of fluid within the vertebral canal, is frequently present.

Tumors in the substance of the cord compress and push apart the component parts. They may merely produce atrophy of the neighboring tissues, but generally cause more or less inflammation. Often they produce transverse myelitis, with all its symptoms. Secondary degeneration takes place just as after other considerable lesions of the cord. The tumor may also produce a localized meningitis and morbid changes in the spinal roots.

Various secondary changes also take place within the tumors themselves, such as softening and formation of cavities. Some cases of syringomyelia—cavities in the centre of the cord—a very interesting pathological condition, though of little practical importance, as it usually produces no symptoms, are merely secondary cavities in the middle of a tumor. Hæmorrhages sometimes occur within the tumor or in the surrounding tissues. This is most likely to take place in those rich in blood-vessels—angio-gliomata and angio-sarcomata.

The secondary changes in the spinal roots and cord just described, and the symptoms induced by them, are produced to a variable degree by different tumors. These effects depend upon various factors, of which the most important are location, size, consistency, rapidity of growth, and tendency to destroy neighboring tissues. The last two qualities are especially important. Rapidly growing tumors produce great irritation, and have a special tendency to produce inflammatory changes. On the other hand, psammoma, a hard but slow-growing tumor, is slow to produce symptoms. Those tumors which have a tendency to destroy surrounding tissues—tubercles, to some extent gummata, but especially carcinomata—produce very intense symptoms. Consistency is also important. Tumors softer than the cord may produce few symptoms. This has been found with cysticerci, for example. Gliomata, also of soft consistency, do not produce symptoms in proportion to their size and rapid growth. This seems to have been true of those which extended almost the entire length of the cord. As to location, those outside the dura mater usually compress the cord less than those within it. The same is true of tumors in the more spacious parts of the vertebral canal—the middle and lower parts of the lumbar region.

It is to be remembered, as regards symptomatology, that some of the secondary effects of tumors, as localized acute myelitis, hæmorrhage into or about the tumor, are sudden in onset, and that, therefore, the clinical history, which is mainly that of gradual progression of symptoms, may present acute exacerbations, often followed by temporary improvement.

Etiology.—Some tumors, as gumma and tubercle, are due to diathetic conditions. In case of the latter, tubercles are almost always found in the lungs or the brain, often in the spinal meninges. Carcinoma is almost always secondary. Parasitic tumors—echinococci and cysticerci—have their usual cause. Beyond this the causes of intraspinal tumors are very obscure. Injuries—blows to the spine, etc.—seem often to be the etiological factor. Exposure, nervous shocks, etc., have been assigned as causes, though their influence in that direction is doubtful.

Symptoms.—Usually the first symptom, and the most prominent one throughout the course of the disease, is pain. This is often intense, and of a shooting, boring, or tearing character. In the beginning it is commonly limited to one side, and radiates along the course of the nerves given off at the level of the tumor. It may be thus localized on one side for a long time before it affects the other side or extends to other parts of the body. Such pain is due to irritation of the spinal roots, and is chiefly produced by tumors of the membranes. On the other hand, in intramedullary tumors, when the substance of the cord is directly irritated, the earliest pains may be in lower parts of the body, and not at the level of the tumors.

There is often pain in the back over the seat of the tumor, also tenderness to pressure. The pain may be increased by movement of the spine, especially if made in such a manner as to compress the tumor. Such movement may produce not only local, but also excentric pain. The latter symptom is probably found in proportion as the meninges, and especially the bone, are involved in the morbid process.

In addition to the pain there is often hyperæsthesia or paræsthesiæ—numbness, tingling, formication, etc.—in

Spinal Cord.

the painful area, and frequently a sense of constriction, or girdle sensation, near the level of the tumor.

Along with the symptoms of sensory irritation just described there are often signs of motor irritation—muscular spasms. They are more marked with tumors of the membranes than with those of the cord. There is often rigidity of the muscles of the back opposite the lesion, sometimes spasms of the abdominal muscles, and not infrequently spasms, even contractures, of the limbs. The latter are sometimes due to irritation of the spinal roots. In other instances they are late manifestations, and due to secondary changes in the cord.

Paralysis is a common symptom, but it usually appears after irritation symptoms have been present for some time. Motor and sensory paralyses may appear at the same time, or one may appear before the other, the motor more frequently preceding, although this depends upon whether the anterior or posterior portion of the cord is first affected by the tumor. The paralysis is usually gradual in its development, beginning with paresis of one member, which increases to paralysis, extends to the other side, and finally involves every part below the seat of lesion. If the tumor is in the cervical region the paralysis usually begins in the arm, though sometimes it appears first in the lower extremity; but usually the four extremities and the trunk finally become paralyzed. When the paralysis gradually increases from paresis to complete paralysis it is not liable to any improvement. But the paralysis does not always progress in this manner. Sometimes there is a sudden and considerable increase of the symptoms, due to an acute myelitis about the tumor, or to hæmorrhage. If the lesion be in the cervical region, sudden paralysis of the four extremities may occur. In such instances there is often subsequent amelioration of the symptoms. The anæsthesia, like the motor paralysis, is usually partial at first, and gradually becomes complete. It generally corresponds in distribution to the motor paralysis. But in some cases of unilateral lesion we have the picture presented by spinal hemiplegia, viz., motor paralysis with hyperæsthesia on one side, and anæsthesia on the other. In that case there is usually anæsthesia at the level of the tumor on the side of motor paralysis, due to injury of the posterior spinal roots. A striking feature often presented is the presence of severe pain in areas of profound anæsthesia. This condition has been termed anæsthesia dolorosa.

Ataxia has been observed in some cases where the posterior columns were compressed. The infrequency of this symptom is, probably, to be accounted for by the existence of the motor paralysis.

Atrophy of muscles is found to the extent that the anterior spinal roots are destroyed, or the anterior cornua are affected, by the secondary myelitis. It is always an indication of the level of the tumor. If the latter be in the upper part of the cervical enlargement, the atrophy is chiefly in the muscles of the upper arm; if in the lower part of the cervical enlargement, in the muscles of the forearm and hand; if in the dorsal cord, in the muscles of the trunk; if in the upper lumbar region, in the muscles of the hip; if in the lower lumbar enlargement, in the muscles of the leg. The extent of the atrophy is especially great when the tumor involves the lumbar cord or the cauda equina, on account of the number of nerves likely to be compressed. In other instances, too, the extent of atrophy may be considerable, because the secondary myelitis often extends for some distance below the tumor, and chiefly in the gray matter.

The electrical reactions are altered only in the atrophied muscles. In these the reaction of degeneration is more or less distinctly marked. In other paralyzed muscles the electrical reactions are normal. The state of the reflexes varies in different parts of the body. In the parts corresponding to the level of the tumor, where muscular atrophy is found, they are usually abolished, while in the lower part of the body both skin and tendon reflexes are increased, and there are often, at the same time, the other phenomena of spastic paralysis. Thus, if the tumor be in the cervical region, the skin and tendon reflexes of the upper extremities may be abolished, while those of the trunk and lower extremities are much exaggerated. If in the dorsal region, the skin reflexes of the thorax or abdomen may be abolished, the reflexes of the lower extremities exaggerated. If in the lumbar region, the patellar tendon reflexes, etc., are abolished; and if the lesion extend sufficiently low in the cord, all the reflexes in the lower extremities may be abolished.

In addition to those already mentioned, other symptoms of profound disease of the cord may be found. Vaso-motor manifestations—heat, more frequently coldness, in the paralyzed extremities, sometimes œdema; symptoms on the part of the rectum and bladder—incontinence of fæces and urine, cystitis, pyelitis, etc.; genital symptoms—impotence, priapism, etc., and decubitus, are more or less common.

A few words as to the peculiar symptoms of tumors at different elevations of the cord. Those in the cervical region are most likely to be attended by rigidity of the spine. They may produce respiratory symptoms, as cough and dyspnœa, also pupillary symptoms, contractraction or dilatation. If in the uppermost part of the cord, symptoms on the part of the cranial nerves may appear—dysphagia, disturbances of speech, sometimes optic neuritis. Tumors in the dorsal region can often be more exactly localized than those in the cervical or lumbar region, because the nerves of this part are not so crowded and do not unite in plexuses. Tumors in the lumbar region of the cord more frequently cause bedsores and paralysis of the bladder and rectum than those in other parts of the cord. The same is true of tumors of the cauda equina. The vesical symptoms are always early, and the paralysis of the bladder is likely to be very marked. When there is more than one tumor, the symptoms of lesions in different parts of the cord may appear. When their number is multiple, the symptoms of some of the tumors may be concealed by those of others.

In a general way, differences may be noted in the symptoms of tumors of the cord and of the membranes. The root symptoms are usually earlier and more severe with tumors of the membranes, while the cord symptoms come on at a later period. Pain, tenderness, and rigidity of the spine, as well as increase of pain on movement, are more common in tumors of the membranes. On the other hand, cord symptoms, paralysis, etc., and especially muscular atrophy, are usually earlier manifestations and more extensive in tumors of the cord.

The course of the disease is variable, depending upon the location, rapidity of growth, etc., of the tumor. Usually pain in a limited part on one side of the body is the earliest symptom, and months or years may pass before other symptoms appear. The paralysis usually begins as a paresis, and increases gradually in extent and intensity. The symptoms may progress steadily, or may be stationary for a longer or shorter time, or there may be a sudden increase of symptoms, often followed by improvement. Sometimes such different periods may alternate with one another. Cystitis and decubitus are usually late manifestations. The duration of the disease is from six months to eight or ten years or more. The average duration is from one to three years.

Diagnosis.—The diagnosis must be based on, firstly, the presence at the same time of both severe irritation symptoms—severe pain, muscular spasm, etc.—and paralysis; secondly, the gradual increase both in the intensity and extent of the symptoms, especially the indications of lateral extension of the disease from one side of the cord to the other; thirdly, local pain, tenderness, and immobility of the spine in the neighborhood of the tumor; also increase of pain on movement. The knowledge of causal relations may assist in the diagnosis. A history of constitutional syphilis should arouse a suspicion of gumma in the cord or membranes. With a primary cancer of the breast, and the clinical picture of paraplegia dolorosa—paraplegia with intense neuralgic pains—there can scarcely be any doubt as to the presence of intraspinal carcinomatous deposits.

Yet it must be acknowledged that it is often difficult or impossible to diagnose the presence of tumors. If soft, and slow in growth, they produce scarcely any symp-

toms. In others the clinical history presented is very obscure. Especially in the beginning, when pain may be the only symptom, is the diagnosis doubtful.

The diseases most likely to be confounded with intraspinal tumors are tumor or caries of the vertebræ, some painful forms of myelitis, and multiple neuritis. In the first there are more pronounced symptoms of disease of the bone, and slighter symptoms of disease of the nervous structures, and deformity appears, sooner or later, to clear up the diagnosis. In myelitis the pains are usually less severe, there is rarely the same kind of extension of symptoms, and the local pain, tenderness, rigidity, and pain on movement of the spine are rarely, if ever, found. In multiple neuritis the tenderness to pressure over the course of the nerves should be a valuable guide in forming a diagnosis.

After a tumor has been diagnosed it becomes next a question as to its locality and nature. The location of the tumor is to be determined by the height of the paralysis and the presence and location of the localizing symptoms—pain, spasm, muscular atrophy, and abolished reflexes. The nature of the tumor may be inferred from the presence of certain systemic conditions, syphilis, tuberculosis, or cancer; or of tumors, neuroma or sarcoma, in other organs. If none of these conditions is found, we can only be guided in our surmises by the general fact that the most common tumors in the cord are glioma and tubercle; in the membranes, sarcoma, fibroma, and gumma.

Prognosis.—The prognosis of intraspinal tumors is exceedingly grave. Only in cases of syphilomata is there much prospect of a cure, and if symptoms have been present a long time, treatment may often fail, even in these cases. Tumors of a malignant type usually cause the greatest suffering, and run the most rapid course. Tumors in the cervical region are likely to run a more rapid course than those of the cauda equina, where there is more free space and the nervous structures are of less vital consequence.

Treatment.—In cases of syphilomata very active treatment with both the iodides and mercury should be instituted. The same treatment should be tried where there is any suspicion of syphilis, for these are the only cases in which a cure can be hoped for. Beyond this the chief consideration is to afford the patient relief by the administration of anodynes. As the disease is often of long standing they must be carefully administered.

Since this article has been in type, Gowers and Horsley have reported the successful removal of a tumor (*British Med. Jour.*, January 28, 1888). The more precisely a local diagnosis can be made, and the less the cord is involved in the growth, the more hopeful will be the outlook for such operations in the future.

Philip Zenner.

SPINAL NERVES are those which emanate wholly from the spinal cord. They are more regular in their structure and arrangement than are the cranial nerves, arising always in pairs from either side of the spinal cord, each nerve having two roots connected with the horns of gray matter, a posterior or sensory root upon which a ganglion is developed, and an anterior or motor root which has no nervous connection with the ganglion. They unite immediately beyond the ganglion to form a mixed trunk.

Comparing this now with the cranial nerves, it will be seen that there is no perfectly clear and well-marked distinction of anatomical characters, for the hypoglossal and spinal accessory arise in part from the spinal cord, and in lower vertebrates they are unquestionably spinal nerves. In human embryos the hypoglossal has a posterior root on which a ganglion is formed. Yet it may be said that on the whole the cranial nerves are formed upon a more primitive type. Animals of a simple structure, like the ascidians, from which vertebrates are derived, have for a body a simple muscular sac, and the nervous apparatus consists of a central ganglion from which proceed two sets of nerves, one conveying impressions from the external surface of the ganglion, another distributing impulses from that ganglion to the muscles which contract the sac. The two sets of nerves, afferent or sensory, and efferent or motor, are entirely distinct, resembling in this the majority of the cranial nerves in man. It would seem that the greatly accelerated development of the anterior pole of the body mainly relates to the nervous system and its coverings, and that the peripheral nerves have not been able to acquire that regularity and symmetry which characterize the other parts of the body, where the development has been slower and the stability greater.

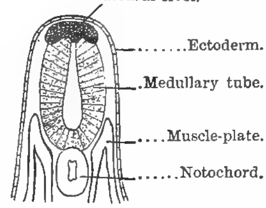

Fig. 3656.—Cross-section of Embryo of Chick before the Appearance of the Spinal Nerves. (After Marshall.)

In the lowest vertebrates the spinal nerves arise by a single root, which conveys both sensory and motor impulses.

In fœtal life these nerves originate as outgrowths from the central nervous system. At the time the medullary groove folds over to form the neuro-central canal, there arises directly along the edges of the seam made by the union a longitudinal band of cells known as the neural crest. (See Fig. 3656.)

This becomes larger at points corresponding to the segments of the body, and pushes out processes laterally which become the posterior nerve-roots. At first these are connected across the back of the cord by means of the neural crest, but as they increase in size they acquire a secondary attachment near the posterior horns of the spinal cord and the crest disappears. The ganglion soon appears as a swelling upon the budding root, and may be covered by an outgrowth from the posterior horns of the cord. (Fig. 3657.)

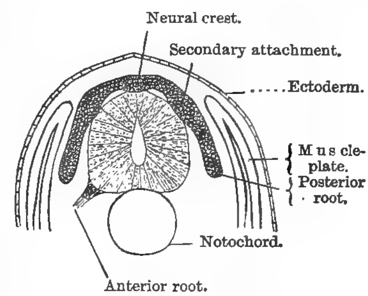

Fig. 3657.—The Same, at a later Stage. (After Marshall.)

Duval, however, considers that it is developed independently, and afterward becomes united to the cord through the posterior root, and thus explains the fact that the trophic centre for the posterior root resides in the ganglion, while that for the anterior root is, as is well known, in the anterior horn of the cord. The motor roots arise later and separately, as distinct extensions from the ventral surface of the cord (Fig. 3658).

The spinal nerves are regularly arranged in pairs, which correspond to the segments or metameres of the vertebrate body. Thirty-one of these pairs are satisfactorily made out, and Rauber has recognized the rudiments of two other pairs which do not (as far as known) leave the spinal canal, but remain in the cauda equina of the spinal cord, the atrophied vestiges of a period when the posterior pole of the body was more developed than at present.

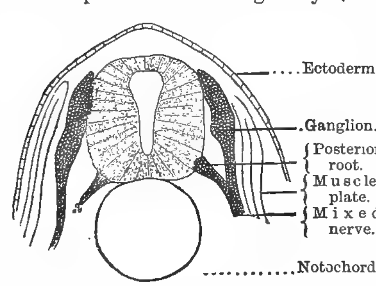

Fig. 3658.—The Same, when the Formation of Nerve-roots is Completed. (After Marshall.)

The nerves pass from the spinal canal through the intervertebral foramina, and are divided into cervical, dorsal, lumbar, sacral, and coccygeal groups, corresponding to those regions of the spine. It was the original intention of Willis to have the names correspond invariably to

the vertebra *under* which the nerve passes out. Thus the fifth lumbar nerve passes out between the fifth lumbar vertebra and the sacrum, and the fifth sacral between the sacrum and the coccyx. He considered the suboccipital nerve, which passes out between the occipital bone and the first cervical vertebra, as a cranial nerve. Vicq d'Azyr pointed out that in its origin and anatomical character it was a spinal nerve, and, therefore, added it to the cervical nerves—which deranged the scheme for that region. The eighth cervical nerve, therefore, emerges below the seventh cervical vertebra, and so on. It will be evident that this method of readjusting the nomenclature occasioned less change in the existing terms than any other scheme would have done. Coues has proposed, however, to rearrange the entire series, and commencing at the first cervical, to renumber all the nerves, naming each from the vertebra *over* which it passes out. This would not only be an advantage in nomenclature, but also represent more accurately the metameric relations of the nerves. As the body has grown proportionately faster than the cord, the central attachment of the nerves is invariably higher than their peripheral distribution.

According to the generally accepted arrangement, the nerves are classified in pairs, as follows:

Cervical nerves	8
Dorsal nerves	12
Lumbar nerves	5
Sacral nerves	5
Coccygeal nerves (two being rudimentary)	3
Total	33

The size of the posterior roots is greater than that of the anterior, as is the case with sensitive nerves generally. It appears to be necessary to have a large number of independent fibres for the conveyance of the multiform impressions from the outer world, while, after these impressions have been transmitted into comparatively simple motor impulses, a less number of separate tracts is required. Stilling carefully determined the comparative area of the cross-sections of the roots in a female subject of twenty-six years, and found the total of the anterior roots to be 35 to 36 square millimetres, while the posterior roots amounted to from 54 to 57 square millimetres.

There is also a variation in the size of the nerve according to the activities of the part of the cord from which it is given off. Those nerves which supply the extremities are necessarily much larger than those which merely go to the body-wall. Not only is the area to which they go larger, but the differentiation of organs is carried to a far greater extent. These nerves are given off opposite the cervical and lumbar enlargements of the cord. According to Stilling, the sixth cervical exceeds the others at the cervical enlargement, while the second is the largest of the sacral nerves.

The ganglia upon the posterior roots are usually found in the intervertebral foramina, except in the case of the sacral and coccygeal nerves. The point of emergence of the trunks of these is a considerable distance below the origins of the nerves, and the ganglia are withdrawn within the spinal canal by the downward growth of the column, and lie between the dura mater and the wall. The size of the ganglia is in proportion to that of the nerve upon which it is found.

The characters which have been given for the spinal nerves are not entirely invariable. There may be certain fibres which do not leave the spinal canal. These may pass directly from one pair of roots to the other with outward convexity (ansa centripetalis, Hilbert), in which case they appear to be related to the fibres of recurrent sensibility, or they may pass from one root with an outward concavity (ansa centrifugalis) to the root next above or below, without connection with the cord. The meaning of this is not very clear; but it should be remembered that fibres may be displaced from their origin in the course of development in such a way as to deceive one as to their actual course. For instance, there is no doubt that fibres run down along the main trunk of the facial nerve, and then turn backward at an acute angle to enter the chorda tympani. It is not by any means infrequent to find a considerable variation in the relative size of contiguous nerves, the fibres usually assigned to one apparently passing to the other. Fine fibres not connected with the nerve-roots may arise directly from the spinal cord and supply the meninges of the vertebral canal. The ganglia may vary. Instead of a single collection of gray matter, there may be several masses scattered along the posterior root in an almost continuous chain, as if in the embryonic development of the root from the cord there had been a continuation outward of the gray matter of the posterior horn. If we attempt to trace the fibres of the roots to their intimate connections in the cord, we find the subject involved in difficulty. The fibres of the sensitive roots on entering the postero-lateral groove may be divided into two groups, which pass on either side the substantia gelatinosa. The external set appear to ascend somewhat, and then either join the fibre-plexus or pass to the anterior horn; the internal set pass, some to Clarke's column, some to the opposite side through the gray commissure, and some pass upward and are lost.

The fibres belonging to the anterior roots are many of them directly derived from the motor cells of the anterior cornu. Some of them, however, come from the lateral column of the cord (crossed pyramidal tract), and we have no absolute anatomical demonstration of their origin.

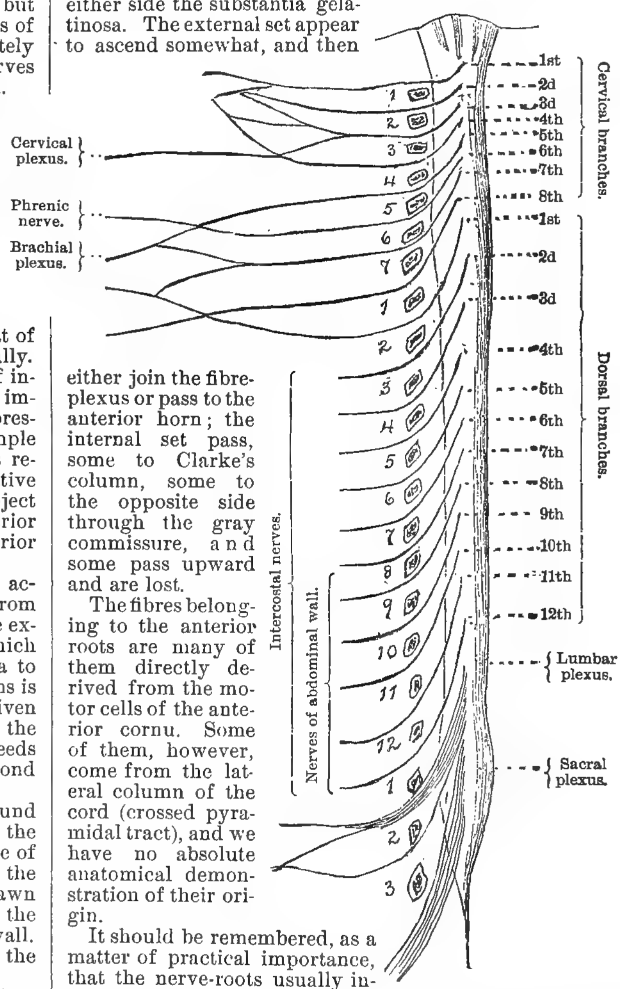

FIG. 3659.—Diagram showing the Relation between the Spinous Processes and the Origin of the Spinal Nerves.

It should be remembered, as a matter of practical importance, that the nerve-roots usually incline downward somewhat from their point of emergence to reach the intervertebral foramina, owing to the lengthening of the canal already adverted to. The first and second cervical are exceptions, the former ascending slightly, and the latter being horizontal. Those below increase in their obliquity from above downward. Thus, while the lower cervical nerves leave the canal the space of an entire vertebra below their emergence from the cord, the dorsal nerves have an interspinal passage of from two to three vertebræ; and for the lumbar and sacral and coccygeal nerves it is still greater, for the cord ends at the first lumbar vertebra. Because of this fact it would be quite

possible to have a lesion affecting a nerve in the spinal canal considerably above its point of emergence, and symptoms might be caused which would be improperly referred to a lower situation if this fact was not taken into account.

The following table, from Tillaux, shows the relation between the spines of the vertebræ and the origins of the nerves.

Nerve.	*Relation to Vertebral Spines.*
Cervical I.	At level of foramen magnum.
II.	A little below the occipital bone.
III.	A little below the middle of the space between the occipital bone and the spinous process of the axis.
IV.	At the spinous process of the axis or above.
V.	Third vertebral spine or above.
VI.	Below 3d, but above 4th.
VII.	From spine of 4th and above, to spine of 5th.
VIII.	From spine of 5th to above spine of 6th.
Dorsal I.	Above spine of 6th to the 7th.
II.	Seventh cervical to 1st dorsal.
III.	From 1st dorsal to middle of interval between it and 2d dorsal.
IV.	From just above to a little below 2d dorsal.
V.	From just above to a little below 3d dorsal.
VI.	From just above to a little below 4th dorsal.
VII.	Fifth dorsal to above.
VIII.	From 5th dorsal to a little above 6th.
IX.	From 6th dorsal to a little above 7th.
X.	From 7th dorsal to a little above 8th.
XI.	From 8th dorsal to a little above 9th.
XII.	From 9th dorsal to a little above 11th.

The five lumbar nerves arise successively from the spine of the 11th dorsal vertebra to the spine of the 12th.

The five sacral nerves and the coccygeal arise successively from the spine of the 12th dorsal vertebra to that of the 1st lumbar.

It follows from this table that any lesion which paralyzes the neck and limbs must be above the 5th cervical vertebra. The phrenic nerve cannot be affected unless the nerves from which it arises (3d and 4th cervical) are involved. The centre for them is above the axis. A luxation of that vertebra is not, therefore, necessarily immediately fatal. A dislocation of the atlas is at once followed by death.

A lesion at the 12th dorsal vertebra paralyzes the sacral plexus at the 11th dorsal, the lumbar, and sacral. If at the 5th dorsal, the abdominal walls are also paralyzed; and at the 3d dorsal the paralysis will reach the 3d intercostal space. If at the 6th or 7th cervical, all the intercostal spaces are paralyzed. These relations are also illustrated in Fig. 3659.

After leaving the intervertebral foramen the mixed trunk soon divides into branches which have special relations to the different portions of the body-wall. A dorsal branch (Fig. 3660) goes to supply the muscles and structures surrounding the neuro-central tube. Some sensitive fibres, which appear to relate to this branch, do not leave the main trunk of the nerve, but run back along the motor root and supply the membranes of the cord. It is those that produce the phenomena of "recurrent sensibility" which occur when the motor root is cut. A neutral branch goes to the muscles of the general body-wall (somatopleure), and a visceral branch connects with the great sympathetic cord and proceeds to the alimentary canal and its annexes (splanchnopleure).

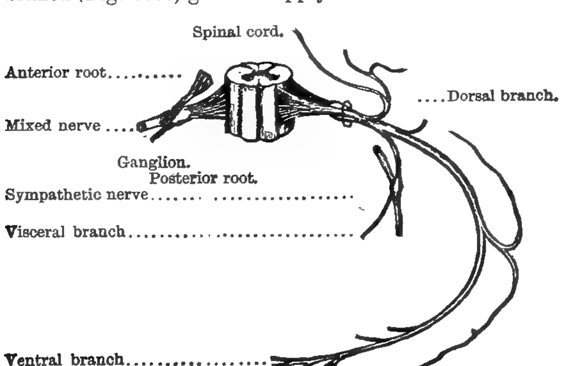

FIG. 3660.—Diagram of a Spinal Nerve.

The visceral branch gives off a fine twig, which, uniting with another from the sensory root, forms the nervus sinu vertebralis of Luschka, which passes in at the intervertebral foramen and supplies the walls of the canal and the bodies of the vertebræ.

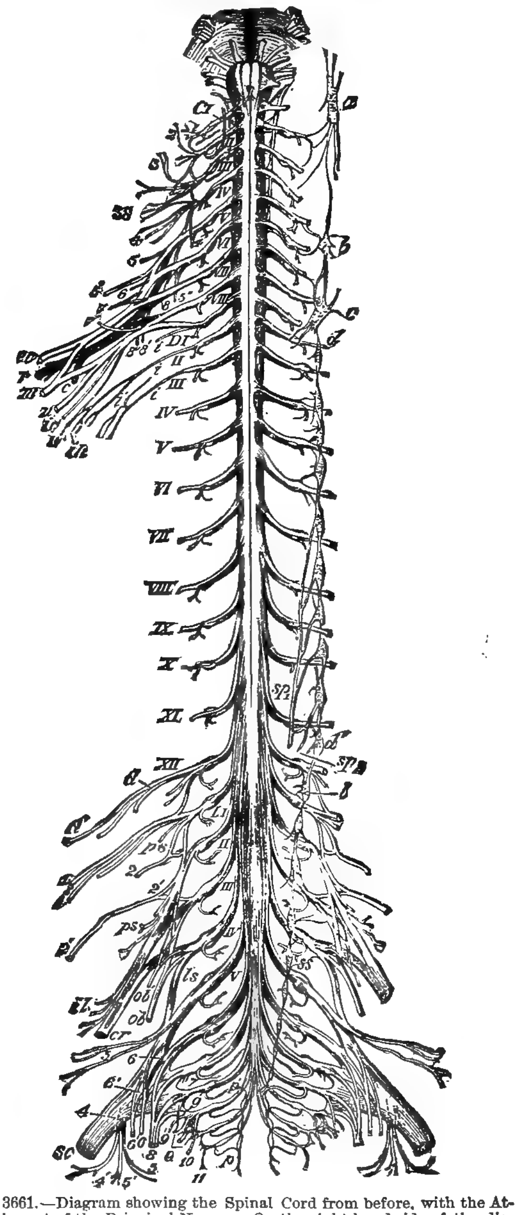

FIG. 3661.—Diagram showing the Spinal Cord from before, with the Attachment of the Principal Nerves. On the right-hand side of the diagram the connections with the sympathetic nerve are shown; on the left-hand side, the plexuses of the anterior roots. (From Ferrier.)

The dorsal or posterior branches are usually much smaller than the ventral, corresponding to the area of the tube for which they were originally intended; but when that tube expands greatly, as in the cranium, the dorsal branches at once increase greatly in size, and that of the first cervical nerve exceeds the ventral branch. They supply the skin and deep muscles on the posterior part of the neck and the back, including the lumbar and sacral regions and a portion of the gluteal region. Two of

Spinal Nerves.

these nerves only have received special names. These are the first and second, known as the suboccipital, and the great occipital nerves. These supply the posterior part of the neck and scalp as far as the vertex. In disease of the cervical vertebræ they may be affected and occasion persistent pseudo-neuralgic pains.

The ventral or anterior branches (see Fig. 3661) form the principal nerves of the body and limbs. They do not usually pass singly to their destination, but after a short course unite with each other to form plexuses, in which the original fibres are mingled intimately. These plexuses form two grand divisions, corresponding to the chief nerves; the upper one, constituted by the anterior branches of the cervical and the first dorsal nerves, is known as the cervico-brachial plexus; the lower one, made up of all the lumbar, sacral, and coccygeal nerves, is called the lumbo-sacral plexus. These, again, have been subdivided into portions which correspond to the parts which they supply. These divisions are shown in the following table, modified from Schwalbe:

Pl. cervico-brachialis	C. 1–4 = cervical plexus.	
	C. 5–8, D. 1 = brachial plexus.	
Pl. lumbo-sacralis	L. 1–3, L. 4 = lumbar plexus.	
	Plexus ischiadicus: L. 4, L. 5, S. 1, 2, 3, 4.	= Sacral plexus.
	Plexus pudendalis, or pudendo-hæmorrhoidalis: S. 3, 4, 5 (S. 2).	= Sacral plexus.
	Plexus coccygeus, or sacro-coccygeus: S. 5, Co.	= Sacral plexus.

C., cervical; D., dorsal; L., lumbar; S., sacral; and Co., coccygeal nerves.

It will be seen that there remain eleven dorsal nerves that are not classed as assisting in the formation of the plexuses. It should be remembered, however, that both the second and eleventh dorsal send branches to the nerves derived from the plexuses, and that they might therefore properly be included in the table. The anterior roots of the dorsal nerves generally pass forward and form the intercostal nerves.

By far the most important of these plexuses are the brachial and the ischiadic, which supply the great nerves for the limbs. The upper extremity is supplied from five spinal nerves, while to the lower and larger limb no less than nine contribute.

The intermingling of nerve-fibres in the plexuses is so great that the nerves which are given off as ultimate branches have most of them an origin from several of the spinal nerve-roots. Many attempts have been made to thoroughly trace out the origin of each nerve. It is almost impossible to do this, and, because of the intimate intermingling of the fibres, different observers have obtained results which are not entirely identical.

It is probable that, as far as regards the formation of plexuses, that the individual variations are very great. The brachial plexus is by far the most regular, because of its peculiar relations to the axillary artery, yet it is certainly very variable both in its composition and its arrangement—so much so that the purely typical form is rarely seen in the dissecting-room. In the formation of plexuses it would seem that there is merely a continuation of a tendency which can be noted throughout the nervous system. Within the sheath of every large nerve the fibres are constantly interweaving among each other

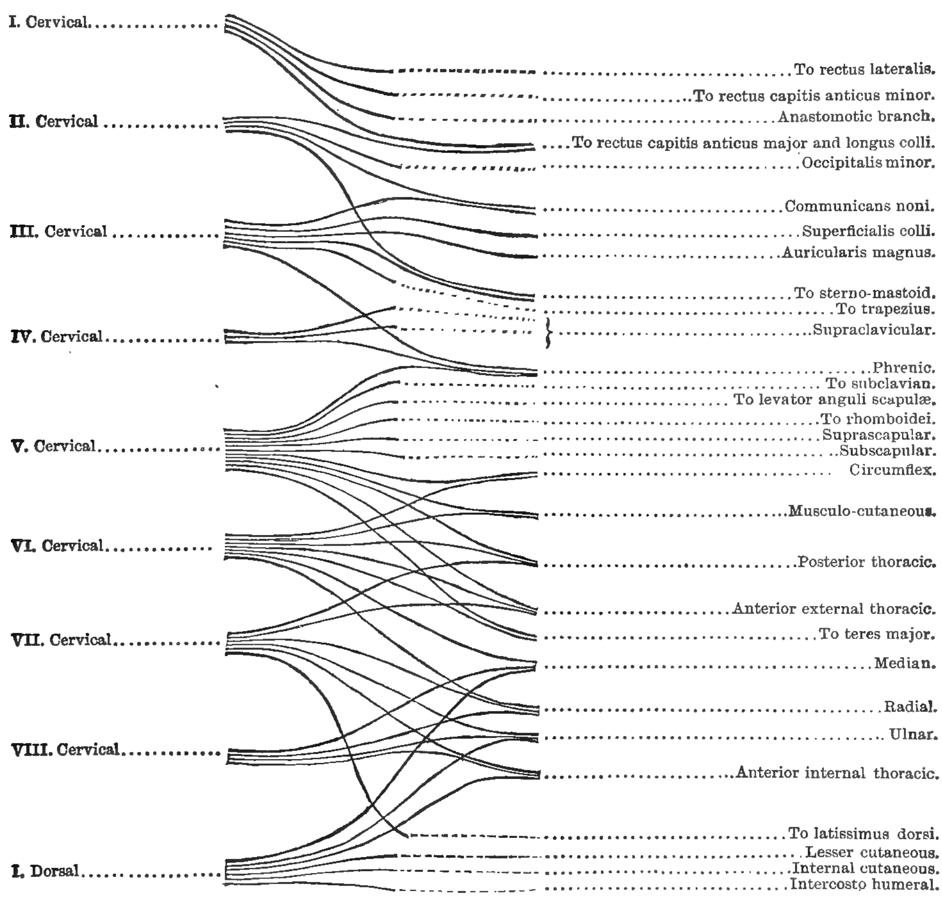

FIG. 3662.—Diagram showing the Origin of the Principal Nerves of the Cervico-brachial Plexus. (After Féré.)

in an irregular manner, so that the relative arrangement changes indefinitely, even in a very short distance.

The question to be solved, however, is not whether the ultimate nerves arise from certain definite cords of the plexuses, but from what part of the spinal cord they can be derived. Féré, after combining the data of others with those from his own dissections, prepared diagrams similar to those shown in Figs. 3662 and 3663, and they may be said to represent our present knowledge on this subject. In studying lesions of the cord it is often necessary to determine from the symptoms the point at which the disorder is situated, and these diagrams permit us to ascertain the approximate area of the cord which is affected when symmetrical impairment of motility or sensibility occurs.

Our knowledge of the muscular system is not sufficient to enable us to fully understand the meaning of this time that the buds for the limbs were formed by the fusion of lateral elements from the somites of the trunk, the relative arrangement of the musculo-nervous canal could probably be cleared up. It will be necessary to await further embryological investigations before this obscure subject can be fully elucidated.

The cervical plexus is formed by the anastomoses of the anterior branches of the first four cervical nerves together with the hypoglossal. The loop supplied by the latter cannot, however, be traced to the hypoglossal nucleus, but is really derived from the first and second cervical nerves, as will be seen in Fig. 3664. This loop supplies all the muscles of the jaw and infrahyoid region, usually assigned to the hypoglossal, leaving for that nerve merely the task of providing motor influence for the intrinsic fibres of the tongue. The hypoglossal side of the loop is known as the descendens noni nerve, and

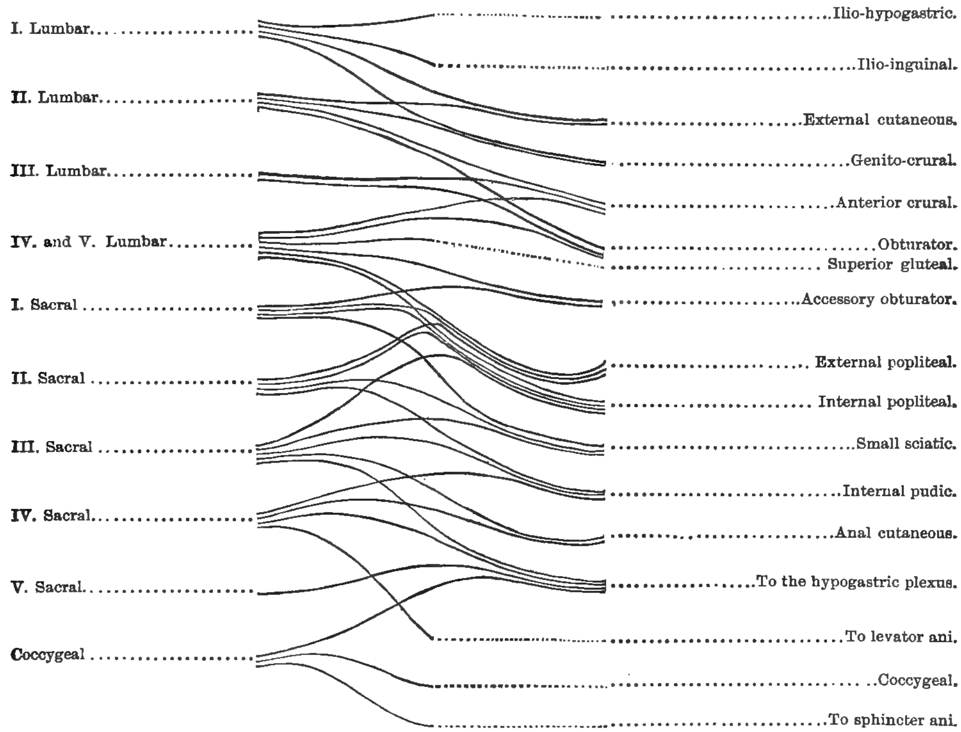

FIG. 3663.—Diagram showing the Origin of the Principal Nerves of the Lumbo-sacral Plexus. (After Féré.)

arrangement. It only appears from a study of the diagrams that those nerves which represent the widest range of activity are those which have the largest area of origin from the cord, and that certain nerves appear to be mere appendages to others. Examples of this may be seen in the internal cutaneous nerves of the arm, which seem to belong to the ulnar, and the obturator, which is related to the anterior crural. It is noticeable that the nerves which supply the distal ends of the limbs are derived from roots farther from the brain than those which supply the proximal ends of the same limbs. As a general rule (subject, however, to many exceptions), the muscles are innervated by the same nerve which supplies the skin over their insertions.*.

It has been surmised that this plexiform arrangement is necessary in order to supply the muscles and other organs with twigs from various sources, so that if one source of supply is injured or cut off the other may be used. It is not quite clear how this can be done. If the entire history of development were known, from the is of some surgical interest, as it usually lies directly on the carotid sheath, and may be in the way when ligation of that vessel is attempted.

The following table[1] gives a general view of the composition of the cervical plexus :

Cervical Plexus of Nerves.

Anterior branch of 1st CERVICAL nerve. Anterior branch of 2d CERVICAL nerve. Anterior branch of 3d CERVICAL nerve. Anterior branch of 4th CERVICAL nerve.	CERVICAL PLEXUS.	SUPERFICIAL BRANCHES (integumentary).	Ascending set.		Occipitalis minor. Auricularis magnus. Superficialis colli.
			Descending set.		Supra-clavicular branches.
		DEEP BRANCHES.	Internal set.	Communicating.	
				Muscular.	Rect. cap. ant. major. Rect. cap. ant. minor. Rect. cap. lateralis.
				Communicans noni.	
				PHRENIC.	
			External set.	Muscular.	Sterno-mastoid. Levator anguli scap. Trapezius. Scalenus med.
				Communicating.	

* This is generally known as Hilton's law, but it was formulated by Peyer and W. Krause, some time previous to the publication of Rest and Pain.

Spinal Nerves.

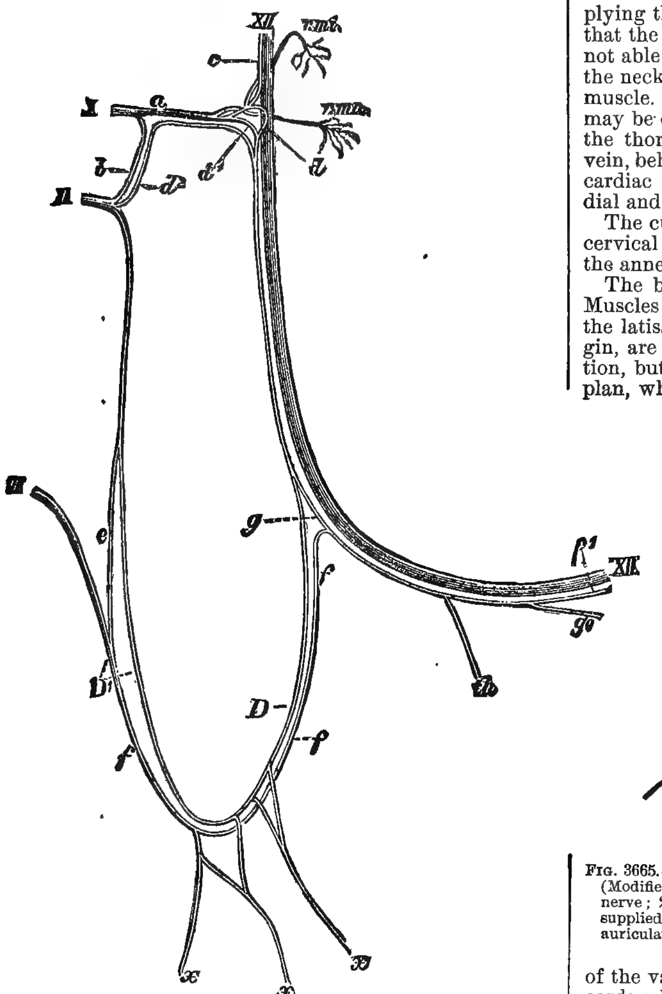

FIG. 3664.—Connection of the Hypoglossal with the Cervical Nerves. (Hall.) XII, Hypoglossal nerves; I, II, III, anterior branch of cervical nerves; D, D¹, rami communicantes noni; *a*, branch of first cervical nerve, which sends a twig, *c*, centrally upward, and gives off twigs *r. ma*, *r. mi*, to the anterior recti muscles; *d*, *d*¹, *d*², descending branches that accompany the hypoglossal; *b*, *e*, loops between cervical nerves; *f*, *f*, descendens noni; *x*, *x*, *x*, twigs for infrahyoid muscles; *g*, the bundle from first and second cervical, uniting with *f*¹ from third cervical; *th*, branch to thyro-hyoid; *ge*, branch to genio-hyoid.

The most important nerve, clinically, is the phrenic, as when it is injured paralysis of the diaphragm immediately ensues, for though it is not the only nerve supplying that muscle, its influence is so much predominant that the other nerves (branches from the intercostals) are not able to do the work. Its most exposed situation in the neck is where it lies in front of the scalenus anticus muscle. It may here be wounded by a stab. It also may be compressed by an aneurism when it passes into the thoracic cavity between the subclavian artery and vein, behind the sterno-clavicular articulation, or by pericardiac effusion as it passes down between the pericardial and pleural cavities.

The cutaneous supply of the neck is derived from the cervical plexus, the areas being approximately shown in the annexed diagram, Fig. 3665.

The brachial plexus supplies the arm and shoulder. Muscles which morphologically belong to the arm, like the latissimus dorsi, although far removed in their origin, are supplied by it. It is subject to very great variation, but it nevertheless may be reduced to a general plan, which may be said to be typical. A great many

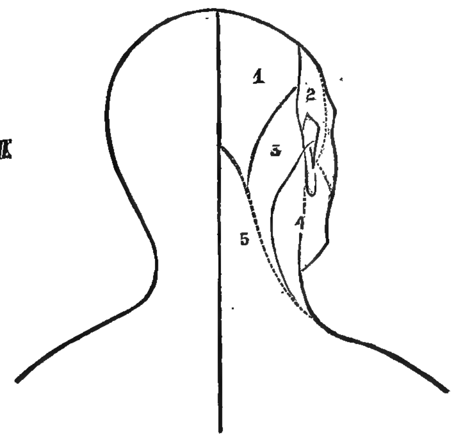

FIG. 3665.—The Nerve-supply of the Posterior Portion of Head and Neck. (Modified from Flower.) 1, Region supplied by the great occipital nerve; 2, region supplied by the auriculo-temporal nerve; 3, region supplied by the small occipital nerve; 4, region supplied by the great auricular nerve; 5, region supplied by the third cervical nerve.

of the variations depend upon the fact that the different cords which compose it may unite sooner or later than usual. Fig. 3666 shows a type to which all variations may be reduced. It will be seen that the 1st dorsal and 8th cervical are the first to unite. Then the 5th and 6th cervical combine, while the 7th remains free. There are thus formed three stems, which Schwalbe calls primary trunks. From each of these there is given off an anterior and a posterior branch. The three posterior branches unite to form a single cord, the anterior branch of the 1st and 2d trunks form another, while that of the 3d trunk remains ununited. There are thus formed three cords which have a definite relation to the axillary artery, lying posteriorly, externally, and internally from it. From these cords the main nerves are given off: from the external the musculo-cutaneous, and one branch of the median; from the internal the other branch of the median, the ulnar, and the internal cutaneous; from the posterior the radial (musculo-spiral) and the circumflex.

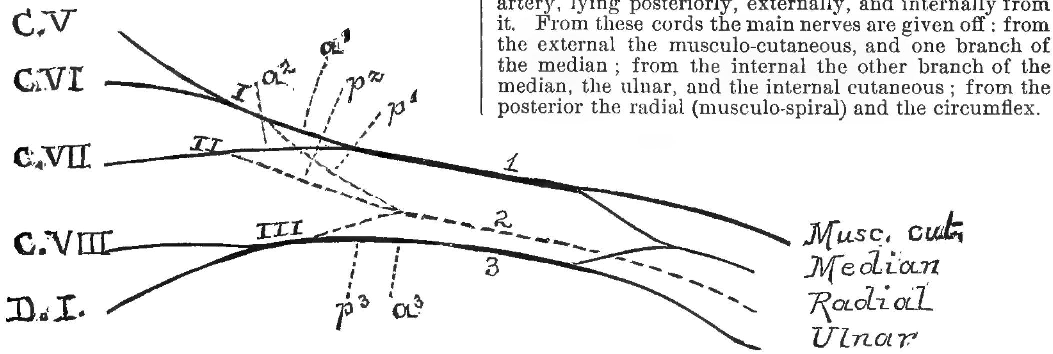

FIG. 3666.—Diagram of a Typical Brachial Plexus. (Schwalbe.) I, II, III, Principal trunks; a^1, a^2, a^3, anterior branches; p^1, p^2, p^3, posterior branches; 1, 2, 3, cords.

The following table[1] shows the other details of distribution of the plexus :

The Brachial Plexus.

Branches *above* the clavicle.	Posterior thoracic (*external respiratory nerve of Bell*).	
	Suprascapular........	Supraspinatus. Infraspinatus. Shoulder-joint.
	Muscular. (8).........	Rhomboidei muscles. Subclavius. Scaleni muscles. Longus colli. Levator anguli scapulæ.
	Communicating (to phrenic nerve).	
Branches *below* the clavicle.	From *inner* cord	Internal anterior thoracic. Internal cutaneous. Lesser internal cutaneous (Wrisberg's nerve). Inner head of median nerve. Ulnar nerve.
	From *outer* cord	External anterior thoracic. External cutaneous. Outer head of median nerve.
	From *posterior* cord.	1st subscapular nerve. 2d subscapular nerve. 3d subscapular nerve. Radial nerve. Circumflex nerve.

Rauber endeavors to simplify the plexus still more by considering the division as arising still further back. His scheme is shown in Fig. 3667. He divides each root at once into an anterior and posterior branch. The latter forms the posterior cord. The 8th cervical and 1st dorsal form the inner cord, then the 5th, 6th, and 7th unite to form the outer. There is thus a division of regions which control the entire arm.

The muscles of the dorsal region, extensors and supinators, are generally controlled by the radial, those of the palmar surface by the musculo-cutaneous above and the median below, the hand being divided between the median and the ulnar. The radial side of the arm is supplied by nerves which have a higher origin in the cord than the ulnar side. The thumb side of the hand is therefore to be considered as that which was originally directed forward.

An inspection of Fig. 3668 will show that a similar law governs the cutaneous nerves of the arm.

One of the mooted points in anatomy is the so-called antero-posterior symmetry of the limbs. Most anatomists hold that the radial side of the arm corresponds with the tibial side of the leg ; but others, among whom may be mentioned Wyman and Coues, suppose that the fibula and the radius are homologous. Wilder advances a theory that the limbs are reversed repetitions of each other, corresponding as an image in the mirror corresponds to the object producing the reflection. It will be seen that the distribution of nerves throws some light on this subject.

The lumbar plexus is buried in the fibres of the psoas magnus muscle, its branches appearing laterally from it or passing out below. The following table[1] shows its general distribution :

Anterior Divisions.	Lumbar Plexus.	
1st Lumbar nerve.	Ilio-hypogastric nerve. Ilio-inguinal nerve. Communicating to 2d lumbar.	Given off by the 1st lumbar nerve.
2d Lumbar nerve.	Genito-crural nerve. External cutaneous nerve. Communicating to 3d lumbar.	Given off by the 2d lumbar nerve.
3d Lumbar nerve.	Part of anterior crural nerve. Part of obturator nerve. Part of accessory obturator nerve. Communicating to 4th lumbar.	Given off by the 3d lumbar nerve.
4th Lumbar nerve.	Part of anterior crural nerve. Part of obturator nerve. Part of accessory obturator nerve. Lumbo-sacral cord.	Given off by the 4th lumbar nerve.

It controls the psoas and iliacus, and the great extensor and adductor groups of the thigh. It sends no muscular branches below the knee.

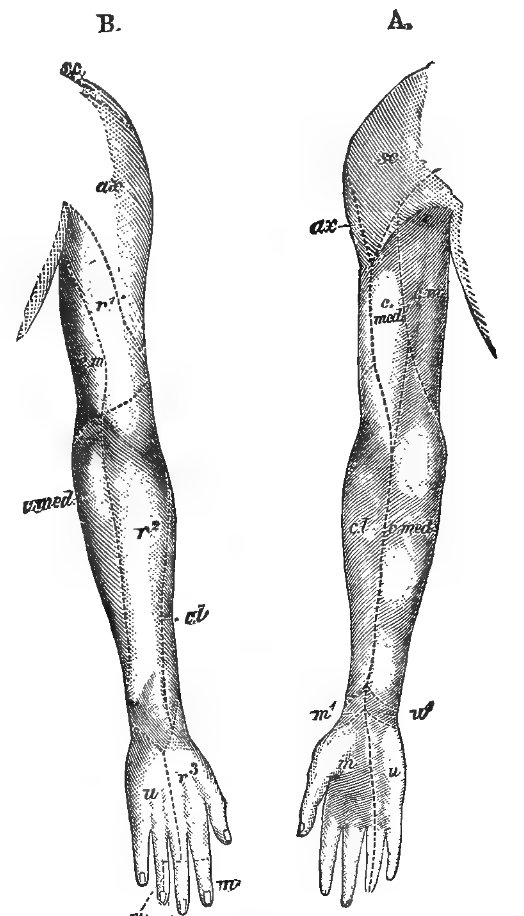

FIG. 3668.—Cutaneous Distribution of the Nerves of the Arm. *A*, Palmar aspect; *B*, dorsal aspect; *sc*, suprascapular nerves; *ax*, circumflex nerve ; *c.m*, lesser internal cutaneous ; *c. med*, internal cutaneous ; *c.l*, musculo-cutaneous ; *r*, radial ; *m*, median ; *u*, ulnar.

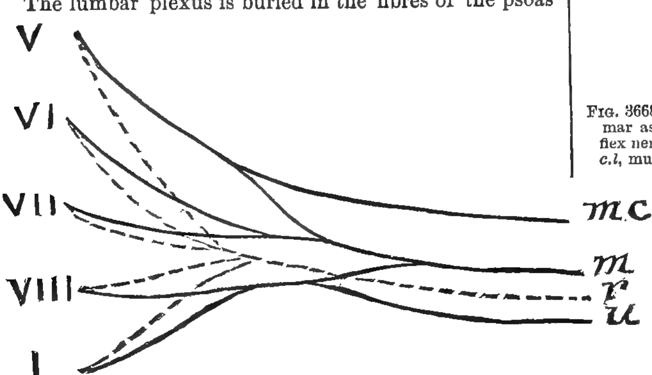

FIG. 3667.—Diagram showing the Plan of the Brachial Plexus, according to Rauber.

The sacral plexus, on the contrary, controls the great gluteal flexor and rotator groups of muscles, the thigh, and all the muscles below the knee. The cutaneous distribution (Fig. 3669) is such that the lumbar plexus (higher roots) generally innervates the anterior surface and tibial edge, while the sacral plexus supplies the posterior surface and the fibular edge. Thus the conclusion arrived at from comparative anatomy and embryology, that the tibial and radial bor-

ders of the two limbs are properly comparable, is here confirmed.

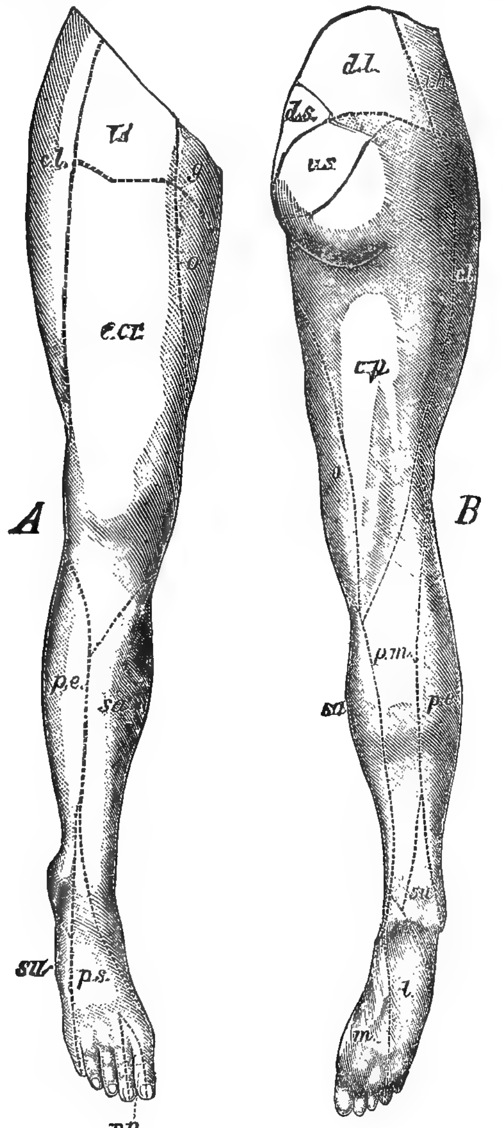

Fig. 3669.—Cutaneous Distribution of Nerves of Lower Extremities. *A*, Anterior view; *B*, posterior view; *d.l*, *d.s*, dorsal branches of lumbar and sacral nerves; *v.s*, inferior gluteal; *i.h*, ilio-hypogastric; *g*, ilio-inguinal; *l.i*, genito-crural; *c.l*, external cutaneous; *c.cr*, middle cutaneous; *o*, obturator; *c.p*, lower sciatic; *sa*, saphenous; *p.e*, external popliteal; *p.m*, post-tibial; *su*, saphenous; *p.s*, musculo-cutaneous; *p.p*, anterior tibial; *m*, internal plantar; *l*, external.

The general distribution of the sacral plexus is shown in the following table:[1]

Distribution of the Branches of the Sacral Plexus.

Superior Glutral.	*Superior* branch.		Gluteus medius muscle. Gluteus minimus muscle.
	Inferior branch.		Gluteus medius muscle. Gluteus minimus muscle. Tensor vaginæ femoris.
Muscular branches.	Pyriformis. Obturator internus. Gemellus superior. Gemellus inferior. Quadratus femoris.		
Articular branches.	To hip-joint.		
Small sciatic.	*Inferior gluteal* branch.		Gluteus maximus muscle.
	Inferior pudendal branch.		*Integument* of perineum. *Integument* of upper and inner part of the thigh. *Integument* of scrotum or labium.
	Cutaneous branch.	Ascending.	*Integument* over gluteus maximus muscle.
		Descending.	*Integument* of inner and outer sides of posterior aspect of the thigh.
Great sciatic.	Articular (to *hip-joint*).		
	Muscular........		Adductor magnus. Semimembranosus. Semitendinosus. Biceps flexor cruris.
	Terminal........		External popliteal. Internal popliteal.
Pudic nerve.	*Perineal*.........	*Cutaneous* or *superficial perineal.*	*Integument* of anal region, scrotum, penis, and labia. Sphincter ani muscle.
		Muscular	Muscles of the perineum.
	Inferior hæmorrhoidal.		
	Dorsal nerve of *penis.*		*Integument* of the dorsum and sides of penis. Branch to corpora cavernosa.

Frank Baker.

[1] Darling and Ranney: The Essentials of Anatomy.

SPLEEN, DISEASES OF THE.

Introduction.—It is now generally admitted that the only ascertained function of the spleen relates to the production of the white and to the destruction of the red blood-corpuscles. Physiologists adduce, in support of this view, the facts that the blood of the splenic vein contains a larger number of white corpuscles than that of the corresponding artery, particularly in cases of splenic leucocythæmia, and that the opposite numerical relations obtain with regard to the red corpuscles. Writers upon physiology also advance the theory that the spleen acts as a vascular diverticulum for the portal venous system, and conjecture, from the invariable presence of uric acid, leucin, and xanthin in the spleen, that this organ is the seat of various undetermined metabolic processes.[1] Since our knowledge of the physiology of the spleen is so meagre, it naturally follows that the relations of splenic diseases to morbid systemic conditions still constitute a *terra incognita* presenting a large and inviting field for original physiological, clinical and pathological research.

Most of the diseases of the spleen are, thus, acknowledgedly interesting rather as concomitants of other morbid conditions than because they exert any known direct influence upon the economy at large. On this account they are generally cursorily considered in systematic treatises upon clinical medicine, being regarded by many authors as of decidedly secondary importance. It is, however, desirable to emphasize the fact that splenic diseases often serve as trustworthy indices of other morbid states, and furnish valuable corroborative evidence of their existence at a stage when prophylactic measures may yet be successfully employed, or roborant treatment advantageously inaugurated.

The writer's opinion, that the spleen should be carefully interrogated in every clinical examination, influences him to preface this article by a few hints in regard to the methods of investigating the physical condition of this organ.

It is important that the diagnostician have definite ideas relative to the normal shape and position of the spleen, inasmuch as diseased conditions susceptible of diagnosis almost always betray themselves by alterations in one or the other of these physical features. The means of physical examination at the physician's command are inspection, auscultation, palpation, aspiration and percussion. The four former modes of investigation afford no assistance in the examination of the normal organ, while percussion gives only approximately correct information, as is evidenced by the discrepancies between the statements of different well-qualified observers. This diversity of opinion may be accounted for by the fact that the spleen varies very notably, in weight and size, in different healthy individuals, under varying conditions,

and at different ages. Gray states that the weight of the spleen at birth is, in proportion to that of the entire organ, as one to three hundred and fifty, and in adult life as one to from three hundred and twenty to four hundred, while the proportion in old age is as one to seven hundred. The same author gives the average weight of the spleen, in adult life, as seven ounces, and the length as five, the breadth as from three to four, and the thickness as from one to one and a half inches, respectively.[2]

One great source of difficulty in accurately outlining the spleen is the occasional superimposition of neighboring organs, viz., of the stomach in gastric tympanites or in the progress of normal digestion, of the colon in distention of that viscus, and of the lung in emphysema or in other pulmonary diseases.

Percussion shows, however, that the average normal adult spleen extends from the upper border of the ninth rib to the lower margin of the eleventh rib, where the splenic flatness imperceptibly merges into that of the kidney, and from about one and a half inch to the left of the spinal column, posteriorly, to the middle axillary line, anteriorly.[3] In practising *percussion of the spleen*, the examiner should place his patient upon the right side, or in the semi-prone position, the body being inclined toward the right, in order that the stomach be prevented, so far as possible, by the force of gravity, from becoming interposed between the spleen and the abdominal wall. It is also useful to employ percussion during alternate full inspiration and complete expiration, in order to discover to what extent the lung overlaps the spleen in these opposite phases of the respiratory cycle, and to ascertain the extent of displacement of the organ occasioned by the ascent and the descent of the diaphragm.

It is only in diseased conditions of the spleen that inspection, auscultation, palpation, and aspiration furnish positive information. If the organ be sufficiently enlarged, inspection may show an unusual prominence of the abdominal parietes in the hypochondriac region, or even in the epigastric, the umbilical, the lumbar, the iliac and the hypogastric regions. Pulsation of the spleen, perceptible to the touch, has been noted in cases of free aortic regurgitation. Auscultation may reveal friction sounds due to peri-splenitis, or, possibly, the hydatid thrill, while the palpating fingers encounter a smooth, ovoid tumor, usually hard, smooth, and rounded above, and presenting a notch or depression in its anterior border. In cases of only moderate enlargement palpation may be usefully employed in the following manner: The patient, being on his right side, is instructed to flex his thighs and legs, thus relaxing the abdominal walls, and to alternately inhale and exhale as fully as possible. The examiner meantime places the thumb of his left hand in the left lumbar, and the corresponding fingers in the hypogastric region, and making deep pressure endeavors to grasp the spleen. Percussion, under these circumstances, shows flatness involving the normal splenic site and the other abdominal regions occupied by the tumor. If the patient assume the genu-pectoral position an enlarged spleen will often fall forward, and it may be made to rise on expiration and to descend during inspiration, if adhesions do not prevent it from so doing. Aspiration may be employed as a means of differential diagnosis in cases of fluctuating splenic tumors, as in hydatids and in abscess.

The chief abdominal tumors liable to be mistaken for an enlarged spleen are renal growths involving the left kidney, fæcal accumulations in the splenic flexure of the colon, gastric neoplasms, abscesses in the abdominal walls, or tumors of the pancreas, of the left lobe of the liver, of the omentum and of the ovary.[4]

Tumors of the left kidney may be distinguished from splenic enlargements by the facts that they are more fixed; that, with the exception of movable kidney, they do not follow the respiratory movements of the diaphragm, and that they are not displaced from their original position by changes in the patient's position. The renal tumor will also usually occupy a position posterior to the site of splenic enlargements, and may cause characteristic urinary symptoms.

Fæcal masses in the splenic flexure of the colon may closely simulate splenic tumors, but they are usually of elongated form, their long axis corresponding to the course of the intestine, in which direction they may be spontaneously or artificially displaced. They may, moreover, be indented with the finger, and may then retain the digital impression, owing to their inelastic character. In many cases fæcal tumors may be removed by the judicious and persistent use of purgatives and of laxative enemata.

Malignant gastric growths generally do not occupy the position assumed by splenic tumors, are usually of smaller dimensions, do not readily change their place during respiration or on palpation, and are attended with a familiar train of diagnostic symptoms.

Chronic abscess of the abdominal walls may be distinguished by its superficial character, its traumatic origin, and by the absence of sufficient causes for splenic enlargements. For the differential diagnosis between tumors of the spleen and *pancreatic, hepatic, omental and ovarian enlargements*, of which the first are less frequent than splenic tumors, and the others, from their position and history, are not likely to be confounded with these, the reader is referred to the writer's article on Abdominal Tumors, in this HANDBOOK.

ACUTE SPLENIC TUMOR. *Definition.*—Sudden enlargement of the spleen occurring in various febrile and infectious diseases, and due either to combined congestion and hypertrophy, or, in cases of short duration, to congestion alone. The physiological enlargements of the organ, incident to digestion and to menstruation, are not generally included in the category of splenic tumors, although, strictly speaking, they might be classified under this heading.

Etiology.—This form of splenic tumor occurs with great constancy in some of the infectious diseases, as in typhoid and in typhus fever, relapsing, intermittent and remittent fevers. It is also generally observed in the course of septicæmia, pyæmia, acute yellow atrophy of the liver, acute miliary tuberculosis, erysipelas, puerperal fever, dysentery, splenic fever, scurvy, glanders, ulcerative endocarditis, variola, scarlatina, cerebro-spinal fever, diphtheria and acute follicular tonsillitis. It is sometimes seen in pneumonitis, acute pharyngitis, primary and secondary syphilis, and in acute coryza, gastro-enteritis and rheumatism. Acute splenic tumor may, moreover, be due to sudden occlusion of the portal vein in pyle-thrombosis or pyle-phlebitis, and to traumatism. Congenital acute splenic tumor sometimes occurs in children whose mothers have suffered from malarial fever during their pregnancy.

Pathogeny.—The splenic enlargement is generally explained by the assumption that the micro-organisms which constitute the *materies morbi* in many of these diseases accumulate in the spleen, owing to the filter-like arrangement of its vessels, occasioning congestion and inflammation both mechanically and by the irritating quality of the excrementitious products resulting from their retrograde metabolism. The discovery of numerous micro-organisms in the spleen pulp, after splenic fever and pyæmia, lends probability to this view of the pathogeny of acute splenic tumefactions, which is, however, not yet universally accepted.

Pathological Anatomy.—In those forms of acute splenic tumor which are of very short duration, the only morbid anatomical change is a more or less intense hyperæmia. Should, however, the pathological process, to which the splenic tumor is secondary, be at all protracted, the spleen, besides increasing in size, even to two or three times its normal volume, becomes soft, and sometimes almost diffluent. Its color is reddish-brown, or reddish-blue, and is sometimes mottled gray and red. Peri-splenitis may exist. *On section* the pulp becomes elevated above the cut surface of the capsule. The Malpighian bodies, which are generally not seen, may be plainly discerned in some cases, and are occasionally notably enlarged, particularly in scarlatina.[5] The trabe-

culæ are ordinarily obscured by the swollen pulp. The microscope shows the essential lesion to be either an hyperæmia, in cases of short duration, or an hyperplastic splenitis chiefly affecting the corpuscles of the splenic parenchyma. The interstices of the pulp often contain an abnormally large number of red and white blood-corpuscles, and some cells of varying size, pigmented, or fatty and granular. These inflammatory changes generally undergo rapid resolution after the cessation of the primary disease. In cases of typhoid and relapsing fevers this retrogressive change is, however, often long delayed, and in malarial disease particularly, when the patient suffers from repeated attacks, or the lesions may persist indefinitely, constituting one variety of chronic splenic tumor.

Clinical History.—An acute splenic tumor, of moderate or even of considerable size, may not reveal its presence by any subjective phenomena, or these may be masked by the symptoms of the primary disease. Often, however, the enlargement causes a vague sense of weight and discomfort in the left hypochondrium, with tenderness on pressure, and occasionally even *pain*, which, although ordinarily dull and constant, may, rarely, be sharp and shooting, radiating even into the left arm and leg. In the latter case, the existence of peri-splenitis may be rationally inferred. Rupture of the spleen has been known to occur in typhoid and intermittent fever and in other infectious diseases, but it is extremely rare and is hardly to be anticipated, except as the result of traumatism. If rupture occur, it will almost necessarily prove fatal from hæmorrhage, shock, or peritonitis. It is desirable that statistics be gathered bearing upon the frequency with which, in infectious diseases, acute splenic tumor is developed in anticipation of the characteristic constitutional symptoms. It is to be hoped that the physician of the not distant future may be enabled, having early discovered the approach of infectious diseases by splenic enlargement, to sometimes adopt efficient abortive measures of treatment. Mosler describes a murmur heard over the spleen during the febrile paroxysm of intermittent fever, and holds the opinion that the murmur is due to contraction of the splenic artery in the cold stage of the fever.[6]

Diagnosis.—In a case of splenic tumor, found coincidentally with an acute febrile disease, the only question requiring attention from the differential diagnostician relates to the exclusion of chronic splenic tumor. The previous history, particularly if it embrace records of thorough physical examinations, may here be of great service. Failing this, the disappearance or persistence of the tumor, after defervescence, will furnish the required information.

Prognosis.—This relates, first, to immediate danger from the splenic tumor, and, second, to the liability to the development of chronic splenic tumor as a sequela of the acute. Life is only imperilled, in acute splenic tumor, by the rare occurrence of rupture; while a chronic tumor is not developed, even in malarial fevers, provided that proper and persistent antiperiodic treatment be adopted.

Treatment.—Therapeutic measures especially directed to the splenic tumor are rarely required. The primary disease takes precedence of this, its local manifestation, and treatment adapted to the cure of this malady will effect all the improvement in the condition of the spleen that can be expected from internal medication. Should the pain be excessive or lancinating, local revulsive applications, as dry cups and iodine, or hot fomentations, together with anodynes internally administered, will generally fulfil the indications for treatment.

Chronic Splenic Tumor. *Etiology.* — The chief causes of chronic splenic tumor are malarial fever or the malarial cachexia, leucocythæmia, and pseudo-leucocythæmia. This form of tumor is also often found in those who have long resided in malarial districts, even although they have never suffered from any form of malarial disease. Of less importance, as etiological agents, are all the causes of mechanical obstruction to the portal system, of which the splenic vein is an important radicle. In this category belong hepatic cirrhosis, pyle-phlebitis, abdominal neoplasms pressing on the portal vein, thoracic tumors obstructing the inferior *vena cava*, mitral and tricuspid valvular lesions, interstitial pneumonitis or fibroid phthisis, chronic pleuritis with retraction or with great effusion, and pulmonary emphysema. Many of these conditions are, however, often found without a coexistent splenic tumor, and even when the spleen is abnormally small from fibroid contraction or from simple atrophy. Syphilis is said to occasionally produce this lesion independently of its own characteristic form of splenic tumor, and, in rare instances, no cause for the enlargement can be ascertained.

Morbid Anatomy.—The size of the spleen is augmented sometimes to an enormous extent. The organ has been known to weigh fifteen or sixteen times as much as in the normal state.[7] Its shape remains unchanged; its consistency is greatly increased, and its color is, as a rule, dark red or brownish-black, but it may be normal or mottled. The capsule is thickened and may be adherent to surrounding viscera, as the result of antecedent peri-splenitis. On section the cut surface is seen to be smooth and indurated. The glomeruli and trabeculæ may be either almost invisible or very distinct. The microscope shows the lesion to consist in chronic hypertrophic splenitis, involving especially the trabeculæ, but often both these and the splenic cells. Pigmentation of the cells in the pulp, of the Malpighian corpuscles, or of the trabeculæ is not uncommon. For the pathological anatomy of leucocythæmia and of pseudo-leucocythæmia, the reader is referred to the articles in this Handbook treating of these subjects.

Clinical History.—The subjective symptoms are essentially the same as those of acute splenic tumor, viz., slight pain, tension, or fulness, and a dragging sensation in the left hypochondrium, sometimes notably increased by the assumption of the lateral decubitus. In some cases there may be splenic ectopia. We may have certain symptoms due to the pressure of the tumor upon adjacent viscera, such as cardiac arhythmia, gastric disturbances, obstruction of the colon, and chronic ulcer of the leg from interference with the blood-current in the ascending venous channels. Gerhardt described a pulsating splenic tumor presenting a double murmur in a case of aortic insufficiency.[8] All the above symptoms are insignificant when compared with those due to the diseases causing the splenic hypertrophy.

Diagnosis.—For the chief differential points between chronic splenic tumor and other abdominal tumors, the reader is referred to the introductory remarks on the differential diagnosis, and for a fuller exposition of the symptoms and signs characteristic of other splenic tumors likely to be mistaken for this form of tumefaction he may consult the remarks made in this article regarding the other causes of splenic enlargement. Acute splenic tumor is easily distinguished by its brief duration, waxy spleen by the pre-existence of suppurative diseases, syphilitic degeneration by the history of a constitutional taint, and hydatids by fluctuation, thrill, and aspiration. If the chronic splenic tumor be due to malaria, the peculiar cachexia of chronic paludism may be present and pigment particles be found in the blood; if to leucocythæmia, the blood will present an excess of white corpuscles; if to Hodgkin's disease, the lymph-glands will probably be enlarged.

Prognosis.—The exact share borne in the lethal issue of any disease of which chronic splenic tumor is a subordinate clinical feature, by the pathological condition of this organ can, with our present knowledge, only be conjectured. If vital organs are affected by pressure, the influence of the tumor can but be prejudicial to the general strength. We can only repeat that the prognosis, as to life, will depend on the primary disease, and *not* on the secondary splenic condition. If new connective tissue has been formed in the spleen or in its capsule, a complete resolution is, of course, not to be expected.

Treatment.—In chronic splenic tumor from malaria, quinine and arsenic are useful, and removal from a malarial district is to be strongly recommended. In any

form of chronic splenic tumor, electricity and ergot may be tentatively employed, the latter perhaps best, hypodermatically over the region of the spleen. Da Costa reports a case of splenic leucocythæmia successfully treated with ergotin thus administered.[9] Ice-bags continuously employed for long periods may render considerable service, probably in the same way as ergot and electricity, *i.e.*, by stimulation of the intrinsic splenic muscular fibres. Counter-irritation, by means of tincture of iodine carefully employed, has been productive of good results. Occasional depletion of the portal system by mild cathartics is to be recommended whenever the chronic splenic tumor is due to portal obstruction. If anæmia and asthenia are present, ferruginous tonics and roborant measures are, naturally, indicated. Extirpation of the spleen may be considered, as a last resort, when the tumor is so large as to produce injurious pressure on important organs, or is progressively increasing in size. Crédé believes that the operation is justifiable.[10] Collier found that out of twenty-nine operations tabulated by him sixteen were performed for the removal of leucocythæmic spleens and were all fatal, while eight of the remaining thirteen patients made good recoveries.[11]

PERI-SPLENITIS. *Definition.*—Acute or chronic, localized or diffuse inflammation of the capsule and of the peritoneal investment of the spleen.

Etiology.—Peri-splenitis is caused by great over-distention of the capsule, as in cases of malarial fever and of other infectious diseases, by extension to the capsule of interstitial splenitis, by involvement of the capsule in inflammations of neighboring tissues, as in perinephritis, in gastric ulcer or cancer, and in general or localized peritonitis. Chronic peri-splenitis often occurs with chronic splenic tumor. It may be a sequel of acute capsulitis, or be coincident with chronic peritonitis. Some writers maintain that peri-splenitis may be caused by chronic alcoholism and by syphilis.

Pathological Anatomy.—In acute peri-splenitis fibrin and pus are formed upon the peritoneal coating of the capsule. In chronic peri-splenitis the capsule is more or less thickened from the development of new connective tissue. It may be adherent, through the medium of this new tissue, to adjacent organs. Its color is lighter than normal, and the new tissue, particularly in localized peri-splenitis, is dense and of cartilaginous firmness. It may have undergone calcification. The new connective tissue sometimes assumes the form of nodules or of papillary outgrowths. In peri-splenitis of apparently syphilitic origin the connective tissue may form small, opaque, whitish plates or disks.

Clinical History.—In some cases of malarial and other fevers a friction-sound is heard over the enlarged spleen during the respiratory movements. This is the first, and in mild cases the only, symptom of peri-splenitis. Severer cases will be attended by the lancinating pain which is characteristic of local peritoneal inflammation, which is aggravated by movements of the diaphragm, or by changes in position, and which may radiate into the left arm or thigh. Beyond this there will be no symptoms or signs until after the development of adhesions between the spleen and neighboring organs, when the spleen may remain immobile during respiration and present certain irregularities and prominences to the palpating fingers. Adhesions may be assumed to exist if there is no enlargement of the spleen during acute infectious diseases, or if splenic dulness persists after the occurrence of intestinal perforation.

Diagnosis.—Peri-splenitis is to be distinguished from perihepatitis over the left lobe of the liver, and from the first stage of pleuritis, particularly of diaphragmatic pleuritis. The differentiation is often very difficult, and is largely based upon the clinical history of these diseases. Thus the effusion of pleurisy, and the larger area over which hepatic friction-sounds are audible will somewhat assist the diagnostician.

Prognosis.—This is invariably favorable in simple cases, since peri-splenitis leaves no after-effect, unless it be pain from traction of an enlarged spleen upon newly formed peritoneal adhesions.

Treatment.—This will embrace measures for the relief of the pain in the earliest stage of the inflammation, such as the application of hot fomentations, of revulsives, and of counter-irritants. For severe pain anodynes may be administered by mouth or hypodermatically. The pain due to traction of the spleen upon peritoneal bands and adhesions may be mitigated by the use of a belt or girdle for the support of the enlarged organ.

INFARCTION. *Etiology.*—Splenic infarction is due to embolism of the splenic arterioles. These vessels belong to the class of arteries known as end-arteries, *i.e.*, they do not terminate in anastomosing capillaries, but in intercellular vascular spaces. The most favorable conditions for the occurrence of hæmorrhagic infarction are afforded by this vascular arrangement and by the absence of valves in the splenic vein, which allows the free regurgitation of venous blood. The emboli causing obstruction of these arteries usually come from the left heart or the aorta, but in pyæmic cases they may proceed from the lungs, or, possibly, from even more remote parts of the body. They consist, either of vegetations from the endocardium, of atheromatous particles, of fibrin detached from thrombi, or of colonies of micro-organisms surrounded by fibrin. Splenic infarctions may be classified as simple and mycotic, in accordance with the character of the emboli which cause them.

Pathological Anatomy.—Simple splenic infarctions are wedge-shaped, corresponding to the conical area supplied by the obstructed arteries, and generally near the surface. The apex of the wedge is directed toward the hilum, while the base often projects above the surface. There may be but one infarction, or there may be many infarctions. The size of the infarction varies ordinarily from that of a pea to that of an egg, but it may be much larger, owing to the coalescence of adjacent areas of infarction. If such a coalescence be established, the characteristic wedge-shaped or conical form may be no longer preserved. On section the infarction is found to be either hæmorrhagic, white, or mixed. In recent cases it is usually firm, whitish in the centre, and red at the periphery. Localized peri-splenitis may be found over the base of the infarction. In cases of longer standing the color is yellowish-white, from pigment absorption and from fatty degeneration of the cells. In some cases an infarction may soften and be absorbed, leaving a cicatrix. Again, it may successively undergo fatty, cheesy, and calcareous degeneration. Rarely it suppurates. The microscope shows that the hæmorrhagic infarction is made up of red blood-corpuscles and of compressed splenic tissues, while in the white infarction the cells are in a condition of coagulation necrosis. Mycotic infarctions are surrounded very early by zones of inflammation, due to the irritation of the micrococci, and the pathological changes soon pass into those of splenic abscess (*quod vide*).

Clinical History.—Simple splenic infarctions give rise to no symptoms, unless from accidental causes they occasion acute splenitis and perisplenitis, diseases described in this article under those headings. They are therefore devoid of importance, inaccessible to diagnosis, and claim no treatment, often being found at autopsies of persons in whom their existence was not suspected. The clinical history and the treatment of mycotic infarctions merges into that of metastatic splenic abscess, to be presently described.

ABSCESS. *Etiology.*—There are two chief varieties of splenic abscess, namely, those due to traumatism, to extension of inflammation from neighboring viscera, or to simple embolism, which are quite rare, and those caused by septic embolism, which are frequent. The former class of abscesses is caused by wounds or contusions of the spleen, by the extension of inflammation from the stomach in cases of gastric ulcer or cancer, by the presense of neoplasms, or, very infrequently, by suppuration of a simple infarction. An abscess of this kind may complicate typhoid, relapsing, or intermittent fever, and sometimes may be developed without known cause. The second variety of abscess is the result of mycotic endocarditis or of pyæmia.

Pathological Anatomy.—Abscesses of the former variety, which, in contradistinction from those due to septic embolism, may be designated as *simple abscesses*, are generally, although not necessarily, larger than the latter. They may lead to the destruction of the entire parenchyma of the organ, the capsule becoming distended with pus and disintegrated splenic tissue. On section the trabeculæ may be seen traversing the diffluent mass, or they, too, may have been broken down. The capsule is indurated, thickened, often adherent to other organs or tissues, and occasionally destroyed by the advance of the abscess toward the surface of the spleen. Smaller simple abscesses may become encapsulated, and, eventually, be reabsorbed, leaving a cicatrix, or they may undergo caseous and calcareous degeneration. Splenic abscesses in any of the above stages, latent as regards symptoms and signs during life, may be discovered at autopsies held upon the victims of various diseases. Large abscesses may rupture and discharge their contents either into the peritoneal cavity, the colon, the pleural cavity, upon the cutaneous surface, into the renal pelvis, or into the retro-peritoneal tissues.

Septic abscesses are ordinarily of small size, because the diseases to which they owe their origin are so often rapidly fatal. Their form may be that of a splenic infarction, from which they often develop, namely, wedge-shaped, the base being directed toward the surface, or it may be very irregular, when the area involved in the infarction has undergone complete necrosis. On section one finds a central mass, which the microscope shows to be made up of leucocytes, granular amorphous *detritus*, and micrococci, surrounded by coagulated fibrin and bordered by a dark congested zone of otherwise normal tissue.

Clinical History.—The symptomatology of splenic abscess is not well made out, on account of the great rarity of the disease. The symptoms of abscesses other than mycotic, as described by those authors who have observed them, are merely those of suppuration in any tissue, and collectively known as hectic fever, together with pain and tenderness in the left hypochondrium, dependent upon peri-splenitis and upon peritoneal adhesions. The pain is said to have radiated, in some cases, into the left shoulder. Rupture of the abscess into the peritoneum causes fatal peritonitis; rupture into the pleura and the bronchi, pleuritis, bronchitis and pneumonitis. In a case of supposed splenic abscess, treated by the writer, pus was abundantly discharged by the bronchial tubes and recovery took place. Rupture into the stomach or into the intestine would be followed by the vomiting or by the dejection of pus and blood, and rupture into the kidney by pyuria and hæmaturia. The physical signs, if the abscess be of considerable size, are those of splenic enlargement with possible fluctuation; but in small abscesses, terminating by caseation and calcification, these signs would probably be absent.

The symptoms and signs of mycotic abscess are usually negative, or are completely masked by those of the coexisting endocarditis or pyæmia. They rarely occasion tenderness, pain, or perceptible splenic enlargement, except in chronic pyæmia, when they may, by the coalescence of several small foci of suppuration, become large and fluctuating. Should the capsule and the peritoneum covering the spleen become involved, there may be considerable lancinating pain and marked tenderness.

Diagnosis.—Simple splenic abscess, large enough to present physical signs, might be mistaken for perinephritis, for pyelo-nephrosis, for sacculated empyema occupying the most dependent part of the left pleural cavity and for hydatids of the spleen. The exclusion of all these diseases but the last one might prove almost impossible, except by exploratory incisions. Some assistance in making a diagnosis might be derived from the fact that a splenic abscess which had not caused adhesions of the spleen would descend on inspiration, which a perinephritic, nephritic, or pleural abscess would not do. Hydatids of the spleen would furnish a characteristic fluid on aspiration. Carcinoma of the cardiac extremity of the stomach and pancreatic tumors may also be mistaken for splenic abscess. The existence of mycotic splenic abscess can generally only be suspected when local signs are developed in pyæmic cases, but the large abscesses of chronic blood-poisoning are more easily diagnosticated.

Prognosis.—Mycotic abscess is not, in itself, fatal, but the pyæmia of which it is a subordinate feature offers a grave prognosis. Simple abscesses are usually fatal, either by rupture or by gradual exhaustion. The prognosis is, however, by no means hopeless, since rupture onto the surface, or in almost any direction save that of the peritoneum, may be followed by recovery.

Treatment.—In suspected cases of beginning simple abscess, active prophylactic treatment must at once be adopted. This treatment will embrace saline laxatives, local abstractions of blood and ice-bags kept constantly applied. Bartholow recommends warm fomentations, turpentine stupes and hot poultices, besides the free administration of quinine.[12] Fluctuating abscesses, simple or pyæmic, should be evacuated with strict antiseptic precautions. The smaller mycotic abscesses are not amenable to treatment.

WAXY SPLEEN. *Etiology.*—Amyloid disease of the spleen occurs under the same circumstances which occasion waxy changes in other organs, namely, during protracted suppurative diseases, particularly in those affecting bone or pulmonary tissue, and in syphilis. Malarial disease is sometimes included in this category of causes, and, in rare cases, no cause can be discovered. This disease of the spleen is rarely encountered except in cases presenting waxy changes in the liver, the kidney, and the intestine.

Pathological Anatomy.—There are two varieties of amyloid spleen. The former is known as the "sago spleen," and the latter as diffuse waxy disease of the spleen. In the former variety the organ is sometimes enlarged, and is sometimes not so. In the latter, the spleen is enlarged, tenacious, and indurated, its capsule being tense and glistening and its edges blunt or rounded. On section the "sago spleen" presents grayish, round, or oval translucent bodies scattered through splenic tissue, which may either be otherwise healthy, or may, also, be involved in the same pathological change. The above-mentioned granules correspond to the Malpighian bodies, and vary in size from about one twenty-fifth to about one-eighth of an inch. In the diffuse variety of amyloid spleen the degenerative change is generally held to have invaded all the splenic tissues, but chiefly the pulp and the trabeculæ. On section the cut surface is waxy and more or less translucent, varying in color from a grayish-red to a dark grayish-brown. It is probable that the waxy change occurs first in the walls of the arteries, in both varieties, and subsequently involves the other structures. The tests for the waxy material are as follows: If Lugol's solution, *i.e.*, the compound solution of iodine, be applied to the cut splenic surface, those tissues which have undergone the amyloid change will assume a mahogany color, the normal tissues merely taking on a yellowish tint. A still more delicate test-fluid is a solution of methyl violet, which imparts a red color to amyloid material, the normal splenic tissues becoming distinctly blue.

Clinical History.—No symptoms can be directly referred to waxy changes in the spleen, unless the organ has become so much enlarged as to cause a feeling of fulness, of weight, or of traction. The other symptoms observed, in any case, will almost invariably be due to the amyloid disease in other organs, as diarrhœa in intestinal disease, and characteristic urinary symptoms in amyloid kidney. There is usually profound anæmia, with all its symptoms, and hæmorrhages from mucous surfaces may occur. On physical examination the spleen is found enlarged and hardened, but it is smooth, retains its shape, is not adherent to any other organ, and is movable.

Diagnosis.—This must ordinarily be based upon the concomitant symptoms of waxy change in other organs, *i.e.*, in the liver, the kidneys, and the intestine, together with the physical signs and the early history of suppuration or of syphilis. Chronic splenic tumor might be er-

roneously considered as waxy spleen, but the history of antecedent malaria, and the microscopical examination of the blood, would exclude both "ague-cake" and leucocythæmia; while the absence of general glandular enlargements would disprove the existence of pseudo-leucocythæmia.

Prognosis.—This is bad, not from the amyloid disease of the spleen, but from the existence of the same change in other and vital organs.

Treatment.—The treatment is almost wholly prophylactic, embracing removal of all possible foci of suppuration and the eradication of the syphilitic cachexia. It is possible that the waxy disease, if not far advanced, may disappear, but it is uncertain whether there be therapeutic means of hastening the resolution.

SPLENIC NEOPLASMS. 1. SYPHILIS.—Splenic syphilis may be congenital or acquired, circumscribed or diffuse. The acquired form is not very common, while congenital splenic lesions are found in perhaps one-fourth or one-third of all cases of hereditary syphilis.[13]

Pathological Anatomy.—In the early stages of syphilis the spleen may be enlarged by congestion, and, perhaps, by moderate hyperplasia, thus constituting one variety of acute splenic tumor, as in other infectious febrile diseases. We have already stated that lardaceous splenic disease, as well as diffuse interstitial hyperplasia, is sometimes caused by syphilis. As these lesions have been described under their respective titles, it now only remains to mention the other pathological change wrought in the splenic tissues by the syphilitic virus, viz., the so-called gummata. These gummata are generally small, some of them being no larger than a grain of millet-seed, others as large as a small bean or lentil. They are, ordinarily, not numerous, and may be either distinctly circumscribed or somewhat diffused. They are usually situated near the surface of the spleen. Syphilomata are, at first, reddish-white, assuming, when less recent, a yellowish tint, and becoming dry, tough, and almost cheesy.[14]

Clinical History.—This is negative. The diagnosis can hardly be made with any degree of certainty. The existence of gummata may be, at most, suspected, if splenic tumefaction, with peri-splenitis, develops during the demonstrated growth of syphilomata in other organs, waxy disease having been excluded.

Treatment.—Acute splenic tumor, due to syphilis, may be reduced by the speedy adoption of specific treatment. Splenic gummata are often readily amenable to treatment with large doses of potassium iodide or to the mixed treatment, while diffuse syphilomata are uninfluenced by any therapeutic measures.

2. TUBERCLE.—Acute splenic tumor, without tuberculous deposits, occurs during the progress of acute tuberculosis. Splenic tubercles, proper, are apparently either always secondary to tuberculous growths in other organs, or appear, simultaneously with widely disseminated tuberculous growths, during the course of acute miliary tuberculosis. In the former case the tubercles are often not very numerous and are visible to the naked eye, varying in size from that of a millet-seed to that of a pea, the largest ones being doubtless composed of several smaller aggregated tubercles. These growths are sometimes called solitary tubercles. They are, at first, grayish and translucent, assuming later a yellowish or cheesy appearance. Their histological features are the same as in tubercles of other organs, and they generally contain numerous bacilli. They are found in the trabeculæ, the capsule, the Malpighian bodies, in the pulp and in the walls of the small arteries[15] (*vide* article Tubercle, in this HANDBOOK).

The splenic tubercles developed in acute miliary tuberculosis are often invisible to the naked eye, and are distinguished with difficulty even by the microscope, since their structure, at an early stage, closely resembles that of the splenic pulp. Tubercles of the spleen are alike devoid of interest for the clinician, the diagnostician, and the therapeutist.

3. MALIGNANT TUMORS, CARCINOMA AND SARCOMA.—These new-growths are hardly ever primary, but usually develop secondarily to other malignant tumors, either by metastasis or by direct extension from a primary neoplasm in the stomach, the liver, the pancreas, and the mesenteric or retro-peritoneal glands. Jeannel states that only seven primary splenic cancers have been reported.[16] Splenic carcinomata are ordinarily of the medullary variety and are often pigmented. These malignant tumors grow with great rapidity, and, if superficially located, may be discovered by palpation. As a rule, they escape detection. Their presence may be inferred if enlargement of the spleen be coincident with the development of malignant growths in other, and particularly in abdominal, organs. These tumors are of little clinical significance, and affect the prognosis unfavorably only in that they give evidence of a more or less wide distribution of the carcinomatous or sarcomatous disease.

4. ECHINOCOCCUS.—This is one of the rarest of splenic tumors. It develops, usually, simultaneously with hydatids in other abdominal organs, particularly with hepatic echinococcus. The disease attacks both sexes with approximately equal frequency, and is chiefly found in middle-aged persons.

The etiology is the same as that of hydatid disease, wherever located, the cause of the disorder being the entrance of the scolices of the tænia echinococcus into, and their establishment in the spleen.

It has been asserted that echinococci of the spleen are generally secondary to other hydatid tumors of the abdominal organs, but this question is not definitely settled.

Morbid Anatomy.—As a rule, there is but one mother-cyst, within which numerous daughter-cysts develop, but there may be a large number of mother-cysts. The hydatids are ordinarily developed from the capsule of the spleen or from its serous investment, but they may originate in the spleen pulp, which, in either case, is destroyed by the pressure of the tumor. The cyst usually increases slowly in size, if uninfluenced by treatment, and, after months or years, finally ruptures into the peritoneum, into some hollow abdominal viscus, as the alimentary canal, into some thoracic cavity, as the pleura or the pericardium, or onto the cutaneous surface. In more favorable cases the cyst may remain stationary in size, occasioning no noteworthy splenic lesion. Suppuration of the cyst may occur, or the cyst may undergo calcareous degeneration, remaining encapsulated and innocuous.

Clinical History.—Small, and sometimes even large hydatid cysts may give rise to no symptoms or physical signs. When, however, a certain size is attained, the patient may complain of weight, tension, and pain, either constant or intermittent, over the region of the spleen, which organ, on physical examination, may be found enlarged in various directions and displacing abdominal and thoracic viscera. Emesis may thus be occasioned by pressure upon the stomach, and obstipation by obstruction of the large intestine. If peri-splenitis coexists, a friction, sound may be perceived. The hydatid thrill is occasionally present, as well as fluctuation. If the cyst ruptures, the symptoms will vary with the organ into which the discharge occurs, and need not be here enumerated, since they are almost identical with those occasioned by the rupture into these various viscera of a splenic abscess, and are described under that caption. Suppuration of the cysts will occasion the familiar symptoms of hectic fever.

Diagnosis.—The establishment of a differential diagnosis involves the exclusion of abscess and of solid splenic tumors. Aspiration will distinguish between these and hydatids, if the characteristic saline fluid, containing hooklets, be obtained. Fluctuation will, when present, exclude solid tumors, and the hydatid thrill is pathognomonic. Small or encapsulated hydatids will elude diagnosis, and it may be impossible to distinguish between simple splenic abscess and suppuration of an hydatid cyst.

Prognosis.—This is very bad, but not hopeless. Rupture does not necessarily occur, but when it does happen

is almost always fatal. The growth of the cyst may be spontaneously arrested, and calcification sometimes renders the tumors harmless, while judicious treatment may materially assist nature in effecting a cure.

Treatment.—The treatment to which the majority of writers lend the weight of their authority consists in the partial evacuation of the cyst, or cysts, by which proceeding the death of the parasites is brought about, and absorption, atrophy, and calcareous degeneration of the remaining contents of the cyst are favored. The evacuation of the fluid should be accomplished by means of a very small trocar, and it is advisable to excite localized adhesions between the cyst and the abdominal wall by means of caustics before aspiration is attempted. The operation and the whole after-treatment should be conducted in accordance with the most approved antiseptic principles. Should suppuration of the sac occur spontaneously, or as a result of aspiration and the ingress of air, a free opening must be made and efficient drainage afforded.

5. Miscellaneous Tumors.—Other and rarer splenic tumors than those above described are fibromata, angiomata, dermoid, and other cysts, besides calcified cysts containing the pentastomum denticulatum. All these new-growths are generally of so small size as to be quite devoid of clinical interest.

Rupture of the Spleen. *Etiology.*—Rupture of the spleen may be either spontaneous or traumatic, but trifling injuries may so often provoke apparently spontaneous lacerations that a sharp dividing line cannot be drawn between these two varieties. The so-called spontaneous ruptures generally occur in cases of acute splenic tumor complicating typhus, typhoid, and intermittent fevers, or other infectious diseases, as well as in abscess, aneurism, varices, or hydatids of the spleen. Traumatic rupture results from violence direct, or rarely indirect, exerted, in almost all cases, upon an enlarged and softened organ. Falls, kicks, and blows, fracture of the ribs, and penetrating wounds are the most common traumatic causes, while acts of emesis, convulsions, and the contortions of parturition have been noted as rarer causative events.

Pathological Anatomy.—Spontaneous rupture usually occurs at a single point, while traumatic rupture may cause lacerations in several different places. Autopsies, in cases of rupture, reveal the diseased condition of the organ which predisposed to rupture, and the presence of blood and *débris* of the splenic tissues in that organ or cavity into which these materials have been discharged. If the patient's life has been sufficiently prolonged, there will be found evidences of the secondary disease due to the rupture, as of peritonitis, pleuritis, or pericarditis. In distinctly traumatic cases there may be contusions or other visible surface evidences of violence, or these may be wanting.

Clinical History.—The symptoms are those of rupture of any vital abdominal organ, and they particularly resemble those following perforation of the bowel, with or without hæmorrhage into the peritoneal cavity. The leading symptoms are a feeling as if some vital organ had suddenly given way, and violent pain over the spleen, soon followed by acute anæmia and rapidly increasing asthenia. Death, either immediately or after a few hours, is the almost inevitable result. Recovery may, however, take place, if the rupture is slight and does not occur into a serous cavity. The treatment, which is usually unavailing, embraces absolute quietude, applications of ice to the abdomen, and generous doses of morphine, hypodermatically administered.

Ectopia and Malformations.—Cases of splenic ectopia, or floating spleen, are comparatively rare. They may result from failure of the suspensory ligament and of the gastro-splenic omentum to retain the organ in place. Such failure may be due to congenital relaxation of the ligaments, to their abnormal length, to traction upon them of an enlarged spleen, or to traction upon the spleen exerted by the contraction of newly formed peritoneal bands. Atrophy of an originally normal or of an hypertrophied spleen may be caused by torsion or compression of the splenic vessels incident to the organ's displacement. Ectopia is to be differentiated from simple enlargement by the aid of physical exploration, and the spleen, having been restored to its normal position by careful manipulations, is to be retained there, if possible, by proper bandages or by abdominal supporters.

The spleen may be displaced, either upward or downward, by abdominal or thoracic diseases of such a character as to forcibly press upon the organ. Among such diseases are to be mentioned tumors, ascites, tympanites, emphysema, pleuritic effusions, pneumothorax and spinal curvatures. Lifting great weights and paroxysms of coughing may act as exciting causes of these displacements, which, in turn, cause various pressure symptoms, among which are vesical and rectal tenesmus, paresis of the lower extremities, emesis, and constipation. The spleen may sometimes escape into a hernial sac, either abdominal or thoracic, and it may, rarely, be found on the right side, in cases of visceral transposition.

Two spleens, either of the same size or of different sizes, have been found in the same subject, and small accessory spleens, of various shapes, are often seen. The spleen may, in very rare cases, be congenitally absent in persons whose other organs are all present, and acephalous monsters have sometimes rudimentary spleens, or no spleens whatever. *William H. Flint.*

[1] M. Foster: Text-book of Physiology, pp. 59, 60. Philadelphia, 1885. Kirke's Handbook of Physiology, vol. ii., pp. 3, 4. New York, 1885.
[2] Gray: Anatomy, Descriptive and Surgical, p. 822. Philadelphia, 1883.
[3] A. Flint, Sr.: Manual of Auscultation and Percussion, pp. 37–39, 1885. Figs. from Weil's Handbuch d. topo. Percussion. Atkinson, I. E.: Diseases of the Spleen, Pepper's System of Medicine, vol. iii., p. 951. 1885.
[4] Loomis: Lessons in Physical Diagnosis, p. 151. New York, 1874.
[5] Delafield and Prudden: Handbook of Pathological Anatomy, p 362. 1885.
[6] Eichhorst: Handbook of Practical Medicine, English translation, vol. iv., p. 42. William Wood, 1886.
[7] Hertz: Ziemssen's Encyclopædia, American edition, vol. ii., p. 629.
[8] Eichhorst: Op. cit., p. 44.
[9] Da Costa: American Journal of the Medical Sciences, January, 1875, p. 117.
[10] Crédé: Centralblatt f. d. Med. Wissensch., June 23, 1883, p. 445.
[11] Collier: Lancet, February 11, 1882, p. 219.
[12] Bartholow: A Treat. on the Prac. of Med., p. 191. New York, 1880.
[13] Atkinson: Op. cit., p. 971.
[14] Mosler: Ziemssen, vol. viii., Am. ed., p. 485.
[15] Delafield and Prudden: Handbk. of Path. Anat. and Histol., p. 365. 1885.
[16] Jeannel: Jaccoud's Nouv. Dict. de Méd. et de Ch., vol. xxx., p. 503.

SPLINTS. The study of splints and methods of splinting is a very interesting one, both to the practical surgeon and to the medical historian.

Ingenuity—and too often misapplied ingenuity—has been expended lavishly in devising splints of the most curious and complicated character, intended to fulfil a number of different indications; splints elaborately carved and often based on false anatomical principles; splints capable of adapting themselves—in a measure—to adults or to children; splints that have been expected to supplement and improve upon the surgeon's faulty work in reduction of fracture, and which have, accordingly, failed of their purpose.

The shops are filled with almost innumerable varieties of splints, devised for the cure of every conceivable fracture. Especially numerous are those for fractures of the femur and of the lower end of the radius. If it is true—which I do not allege—that no obstetrician considers himself eminent in his specialty until he has devised some modification of the obstetric forceps which shall bear his name, it is much more true that almost every surgeon who has written a book—and many who have not—invents some special splint.

It is undeniable that some of the splints stand for a principle, and deserve permanent recognition. The vast majority, however, are relegated by the succeeding generations into oblivion with their authors. This fact is strikingly impressed upon the reader of the surgical works of the last century and the early decades of the present. Here, as in regard to other therapeutic agencies, the pendulum of medical opinion has swung at times from extreme to extreme.

John Bell declared the appliances for treating fracture in his day to be "instruments of torture more terrible

than those used by the Inquisition for that purpose," and substituted therefor much simpler means. Such complicated engines, intended to war against deformity, are not without their types at the present time.

Looking at the other extreme of opinion, we find that at times certain reputable, but misguided, surgeons have actually advocated the treatment of many or all fractures of limbs with no splint save a roller bandage! And others have even done away with this, preferring absolutely nothing. Such absurdities as these are probably the natural revulsion following the contemplation of limbs permanently deformed from splints improperly devised and unskilfully applied.

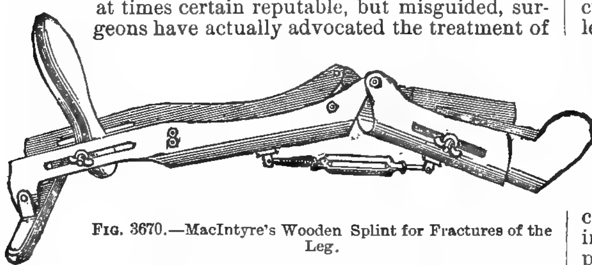

FIG. 3670.—MacIntyre's Wooden Splint for Fractures of the Leg.

Those surgeons who are pre-eminently successful with their fracture cases are not necessarily the ones who have the largest armamentarium of ready-made splints, of myriad shapes and sizes, wherefrom to select for the treatment of any given case. In fact the reverse is often true, and the greatest surgeon possesses few or no stock-splints; but, from splint materials nearest at hand, or readily obtained, makes at short notice for each case a separate and differing splint; one that shall vary with the infinite variety of individual requirements, and which is therefore apt to be better than the ready-made article.

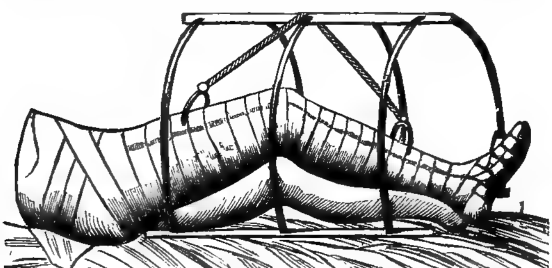

FIG. 3671.—Suspension of the Leg from a Wire Cage.

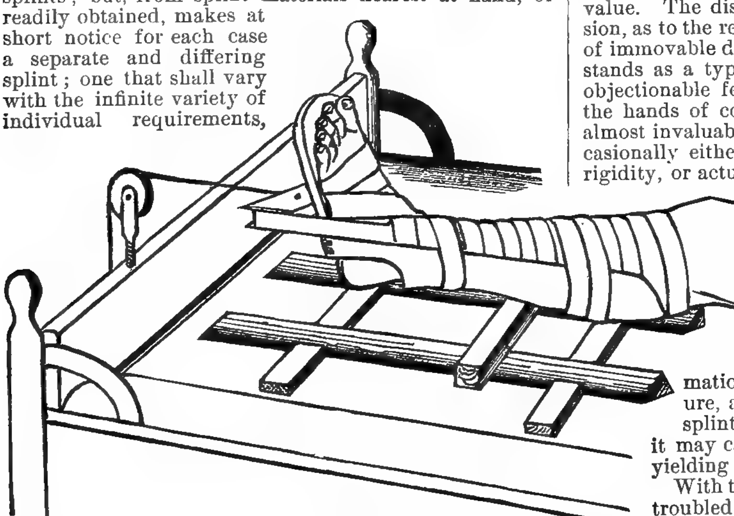

FIG. 3672.—Volkmann's Sliding Leg-rest.

To effect this, a certain degree of deftness and ingenuity is necessary; but this is true of all branches of surgery. And the man who is lacking in this essential will do wisely to choose for his field another department of medicine.

In this article will be discussed mainly the materials used in splinting and the modes of application. Only incidentally are appliances peculiar to some special bone-lesion named, and these are more appropriately studied in conjunction with the phenomena, subjective and objective, which call for their application. Accordingly, the reader is referred for such information to the appropriate headings, as Fractures, Pott's Disease, etc.

Splints are usually divided, for convenience of classification, into two broad groups: the rigid and the plastic. The latter are those composed of substances capable of being made to assume a soft and pliant condition, and subsequently of hardening and maintaining the shape into which they have been modelled. The plastic splints have been in turn subdivided into movable and immovable, which classification seems to the writer an utterly useless one, inasmuch as each and all members of the "immovable" plastic group can at will be so fashioned as to become easily capable of removal.

Not as to *substance*, but as to *method* of splinting, the division *immovable splints* becomes of some practical value. The discussion is not yet ended, in the profession, as to the relative value, in acute injuries, of the class of immovable dressings of which that made of gypsum stands as a type. They have certain advantages; their objectionable features are also now well recognized. In the hands of competent and experienced men they are almost invaluable at times. In other hands they are occasionally either inefficient as a means of maintaining rigidity, or actually dangerous to life or limb. Besides a modicum of experience in the technique of their application, it is essential to the well-being of the patient that the surgeon should recognize certain fixed limitations to their employment. An immovable splint should never be applied to a limb immediately upon the receipt of the injury, or within a few hours thereafter. Considerable inflammation and swelling inevitably follow the fracture, and continue for several days; and as the splint under consideration encircles the limb, it may cause agonizing pain by opposing an unyielding barrier to this swelling.

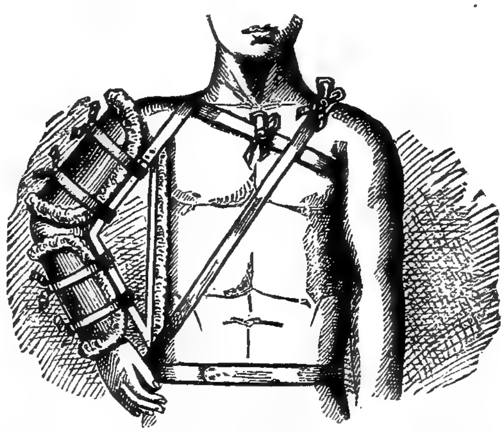

FIG. 3673.—Adaptation of the Double-inclined Plane to the Upper Extremity.

With the ordinary removable splints a patient so troubled could easily free himself. Not so in this case; and if the surgeon be a country practitioner, and hardly able to call again soon, the outcome is occasionally most deplorable. From obstructed circulation gangrene of the point of greatest pressure, or even of the entire extremity, may supervene. This result is, fortunately, rare, but as a danger it must be borne in mind.

Should the patient with fracture be seen first at a period when the inflammation and consequent swelling are at their height, it would probably be wise to wait and not attempt reduction then, unless the fragments be in a decidedly bad relation to each other. But certainly, if splinting be attempted, here is another counter-indication to the use of the immovable method. Upon the subsidence of the congestion the limb will quickly resume its normal size, and a splint closely fitting the limb yesterday may to-morrow be so loose as to aid little in immobilization. The surgeon will consequently have either to cut out a longitudinal strip of the splint, and then by bandage or straps narrow it transversely, or what is probably better and simpler, to remove it and make a new one; either expedient being more annoying and tedious to the attendant than the application of some simple, temporary, removable splint.

It cannot be gainsaid that it is a most desirable thing to have a fractured member freely exposed to the surgeon's eye; and that this is impossible by the immovable method is a strong objection to it. If a strip be cut out, as just mentioned, then we cease to be discussing *immovable* splints, for such a splint can easily be sprung off by the patient himself.

In recent years even the time-honored roller-bandage, wherewith the limb is to be swathed from the digit-tips to above the splint-top, has often been discarded, and wisely. A properly applied splint should rarely cause much circulatory obstruction; and it is well for the surgeon, at least early in bad cases, to be able to watch the whole length of the limb.

The proper time, then, for the application of an immovable splint is after the swelling has completely disappeared, and not before. Even now the limb must unavoidably atrophy somewhat from disuse, so that what was originally a closely fitting jacket will become less so; but this may not now interfere greatly with its practical usefulness.

It is greatly to be desired that a patient shall not be confined to his bed, or even to his room, when avoidable; and in certain fractures of the lower extremity the immovable splint gives us a means, probably better than any other, of permitting locomotion while yet the bone is knitting, with safety to the case.

We may name, among the rigid, non-plastic, splint materials in more or less common use, the following: Wood, tin, sheet zinc, telegraph wire, wire gauze, glass splints.

Besides these, there are many substances used, in temporary or field work, in the absence of more usual means, as plaited unbroken straw, bundles of rushes or stout grass, small fagots of twigs. In fact, the list is almost limitless.

Belonging to a somewhat plastic group are the

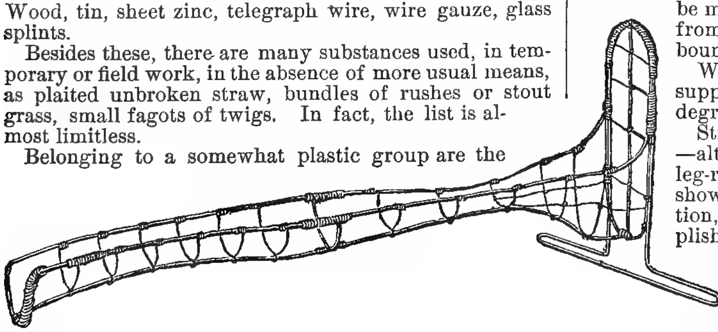

FIG. 3675.—Wire Leg-splint, with Foot-piece and Horizontal Rest.

following: Pasteboard, felt, leather, fresh bark, vulcanized rubber, celluloid, veneering.

Substances of an entirely plastic nature, which are sometimes employed: Plaster-of-Paris, silicates, gutta-percha, paraffine, stearine, starch, dextrine, chalk and gum, glue, glue and zinc oxide, tripolith, clay, shellac cloth or paper, collodion cloth or paper, adhesive plaster.

Among the rigid splint-materials wood is most used. Any thin board will do, preferably one splitting and working easily. A piece of pine shingle will often serve our purpose excellently, where a simple straight splint is required. This must be cut of the desired shape, and then properly padded on the side next the skin. The padding is not to be left loose, but is to be bandaged, or strapped with adhesive strips to the splint. In lieu of this, a method which I often employ is to cause either cotton or wool sheet-wadding—cut of the required size and of double or triple thickness if needed—to adhere to the splint by a few strokes with the paste-brush. This saves quite a little time.

The term "coaptation-splint" is usually employed to designate an affair of thin wood, backed by thinner leather or cloth, and split through at frequent parallel intervals down to the backing; thereby permitting this short splint to be wrapped around the limb just opposite

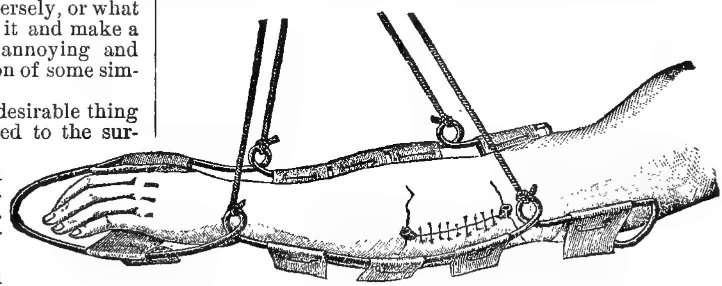

FIG. 3674.—Wire Splint for Horizontal Suspension of the Arm.

the line of fracture. It is often used to prevent lateral motion, in conjunction with some extension apparatus.

Carved and elaborately contrived wooden splints innumerable are in the market. Fig. 3670 indicates one, as a sample. This one, like almost all of them, can be perfectly supplanted by a plastic splint, with or without a telegraph-wire skeleton, and which can be made and fitted in place by the surgeon in half an hour.

Fracture-boxes properly belong in the list of wooden splints. They are generally elevated, to permit of easy return circulation, and have hinged sides. In the inflammatory stage of a compound fracture it may be wise to rest the limb in such an apparatus, dressed and bolstered with small cheese-cloth bags filled with moistened antiseptic sawdust, bran, or peat. At the present day, however, fracture-boxes are not much in vogue.

Although not strictly a part of the subject, it may be well to note that heat and annoyance from weight of bedclothing on the lower limb may be avoided by the use of a protecting cage. Such a contrivance can easily be made in a few minutes with three half-hoops from a barrel, and three laths, the whole being bound together firmly at the points of contact.

With a similar, but somewhat stouter, cage a supporting point can be given for a moderate degree of suspension, as indicated in Fig. 3671.

Still another simple and practical apparatus —although not a splint—is Volkmann's sliding leg-rest, made of three-sided wooden strips, shown well in Fig. 3672. By diminishing friction, it enables extension to be effectively accomplished with a minimum of weight, and is much less cumbersome and expensive than the railways, with wheels, etc., for the same purpose, over or under which the leg rests or is slung.

Fig. 3673 shows a simple and satisfactory means of adapting the double-inclined plane to the upper extremity. In the treatment of fractures of the humerus some degree of abduction is often desirable, and Middeldorpf's wooden triangle is one method of accomplishing this.

In splinting the shaft of the femur the posterior double-inclined planes have been generally supplanted by the wire anterior splint of Nathan Smith, which better accomplishes the same object. Three main methods are used here after reduction: *a*, Simple immobilization by any means; *b*, immobilization plus horizontal extension; *c*, immobilization plus elevation, both leg and thigh being in flexion to relax muscular traction on the fragments.

Where the fracture is a very oblique one, the frag-

ments readily sliding past one another after reduction, shortening will probably best be limited by horizontal

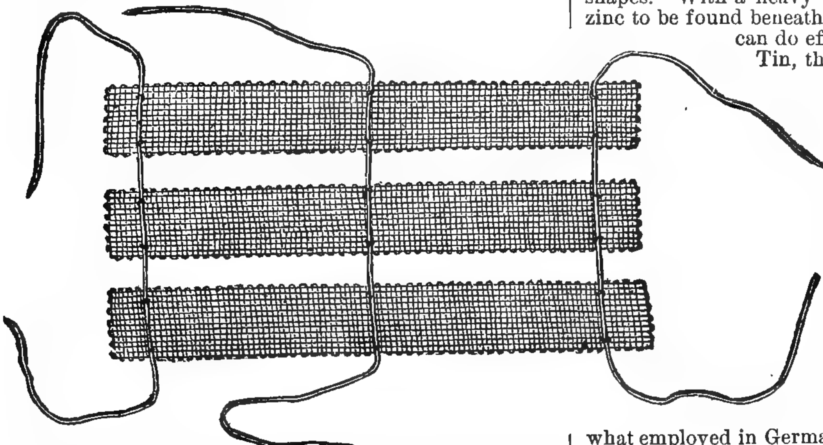

FIG. 3676.—Strips of Wire Gauze, bound together, ready for Application.

extension. In Smith's method extension cannot be effectively accomplished, the splint being fastened to the thigh above the point of fracture and to the body. However, some modification, as Hodgen's, in which the pelvis is not reached by the splint, may permit effective extension by this means.

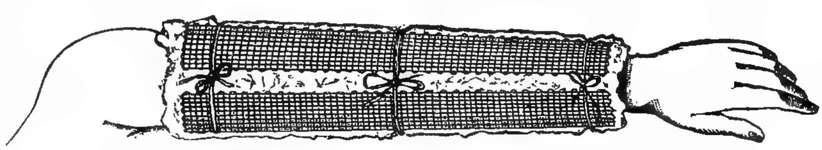

FIG. 3677.—Wire-gauze Splint, with Cotton Padding, applied to the Arm.

Smith's splint, easily made of bent telegraph wires by anyone, seems worthy of much attention, as representing a principle. It has been discussed under Fractures. Regarding the upper extremity, the same idea is illustrated in Fig. 3674.

Wire of telegraph size, or larger, is much used to-day, either embedded in plastic splints as a stiffener, or as a skeleton frame, simple in manufacture and easily made aseptic. Such a wire leg-splint, with foot-pieces and horizontal rest, is shown in Fig. 3675. Sheets of wire gauze, cut of the proper size, are sometimes employed, properly padded—Figs. 3676 and 3677.

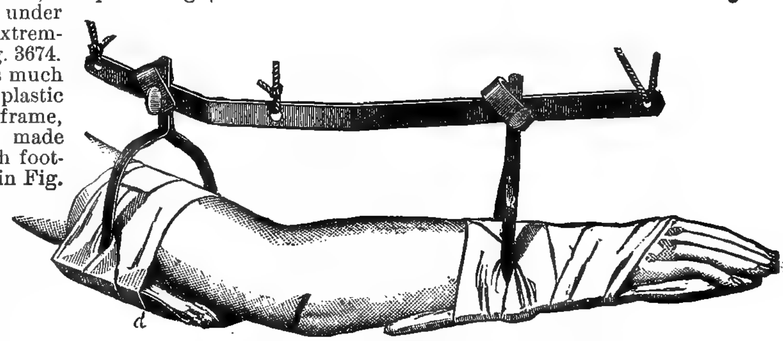

FIG. 3678.—Esmarch's Apparatus for Suspension of a Limb.

An excellent example is seen in Fig. 3678, of a simple iron suspension-splint, arranged to permit easy freeing for passive motion and change of angle. This is a device of Esmarch, from whose works several cuts in this article are taken, others being after Hueter, Volkmann, Neuber, etc.

Metal is in very few instances employed directly in contact with the tissues in splinting—for example, in Malgaigne's hooks for fracture of patella or their modifications, and in Hahn's nails, or screws, etc., for excisions.

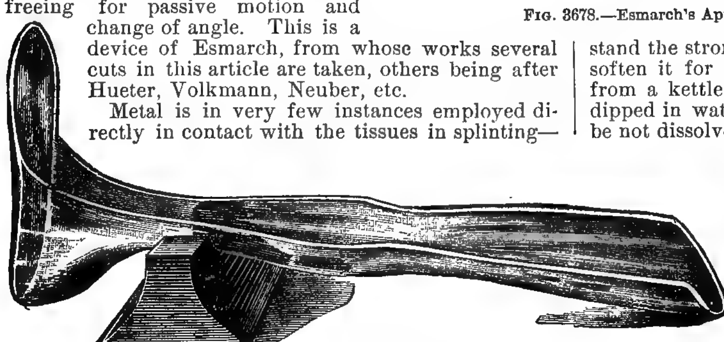

FIG. 3679.—Neuber's Glass Splint.

Sheet-zinc splints are in one sense plastic, since they can be bent and hammered with moderate ease into desired shapes. With a heavy pair of shears and the sheet of zinc to be found beneath almost every stove the surgeon can do effective work.

Tin, that is, tinned sheet-iron, if of ordinary thickness, is rather too flexible for use in extemporized splints. It can be bought stamped into fairly rigid shapes, as for shoulder-caps and Colles'-fracture dressings, etc.; but, as previously remarked, properly extemporized splints are very apt to be best. Narrow strips of tin, with a number of nail-holes driven in them to hold the plaster, are often employed between the layers of a gypsum splint to effect rigidity with slight weight.

The glass splint—such as that of Neuber, Fig. 3679—is somewhat employed in Germany, especially where continuous irrigation or wet dressings are intended. It can easily be rendered aseptic, but its cost and brittleness render it practically out of the field.

Turning now to the more or less plastic group, we find as its most prominent member pasteboard. Of various thicknesses, from mill-board or binder's-board downward in the scale, decidedly cheap, light, and easily moulded, it is an excellent splinting material, and one greatly used in place of wood in New York. It can be obtained thick enough to stand the strongest strains, if doubled. The best way to soften it for plastic purposes is to hold it in steam, as from a kettle, until it yields readily to pressure. If dipped in water, be careful that too much of the sizing be not dissolved out. For short splints the covers of an old book can always be utilized. Fig. 3680 indicates a simple method in which stout pasteboard can readily and without softening be made to form an angular splint for the elbow. Two lines running lengthwise, and the width of the limb apart, are to be barely scratched, to insure the pasteboard bending along them. The transverse line is also scratched, and then cut through from the edges as far as the longitudinal lines. The splint being firmly tied at any desired angle by cord passed through holes in it, is padded to fit. Fig. 3681 shows the same splint applied.

Fig. 3682 is a mill-board model for a shoulder-cap.

The lines A B, C E, and D E, are to be cut completely through. Fig. 3683 shows—the shading, however, being omitted—the inside of the same when in shape for application. The angles C B E, and D B E, in the former figure, are seen to cross one another in this, strengthening this part of the splint. Through the holes indicated the cord is passed which holds the splint in curvature. A moderate amount of steaming or soaking makes the shaping a more easy matter. The interior is, of course, padded with wadding. These examples are merely a few of the many ways in which pasteboard and similar material can be used.

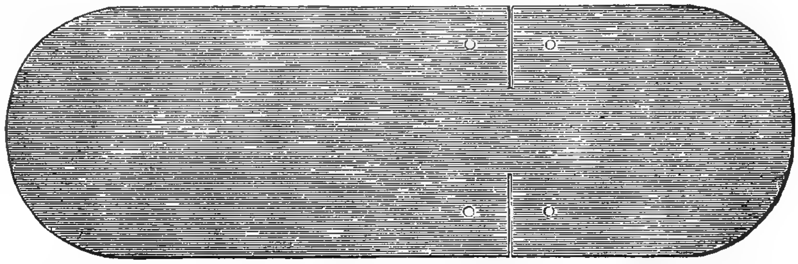

Fig. 3680.—Pattern of a Pasteboard Arm Splint.

Felt—well stiffened by shellac—is not commonly available for extemporaneous splinting, and is rather expensive. It is moulded by exposure to either moist or dry heat.

Either sole or bridle leather may perhaps be found at hand, and soaked in hot water it becomes quite pliable, and subsequently and rapidly stiffens. In country practice fresh bark, from most smooth-barked trees, especially if taken during the time that sap is rising, can be modelled sufficiently well for good work.

Of late, veneering has been considerably employed in one or two of our hospitals. It comes in very thin sheets of white-wood, extremely cheap. Hot water renders it almost as easily bent as pasteboard, the new shape being retained when dry again.

A very valuable splint is that introduced by Schede, of Hamburg—made of vulcanized rubber. This, in thin strips, can be bent to the desired shape by immersion in very hot water, or by oiling and heating, as with a spirit-lamp. When cold it is entirely rigid, and can be easily rendered aseptic.

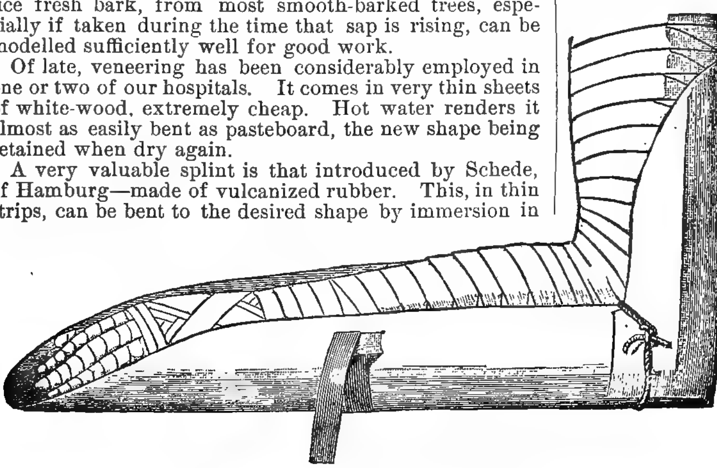

Fig. 3681.—Pasteboard Arm Splint in Position.

Celluloid splints may be substituted for the vulcanite, and moulded somewhat by the use of boiling water. It would hardly do to use oil and the lamp with them, celluloid being almost as inflammable as gunpowder.

The list of entirely plastic materials which I have given comprises several which are not commonly practicable, nor perhaps even desirable, as a first choice. Probably the oldest, as it is also the best, of the plastic splint materials is plaster-of-Paris (gypsum). This substance, after being pulverized finely and heated so that its water of crystallization—which is about one-fifth of the gypsum—is driven off, is in fit condition to use. If it is now wetted, it will reabsorb water and crystallize (set) into a mass almost as hard as stone. It is an interesting fact that, if in making the gypsum anhydrous the heating be carried too far, the "setting" will thereafter not occur, the affinity for water being destroyed. The objections to plaster are few—the only urgent one being its relative weight. This can be in part overcome by a method to be mentioned subsequently. The advantages of plaster are numerous—it sets quickly, and yet not too rapidly for a skilled worker; it is very cheap; is easy and not sticky to handle; is porous, and does not shrink in setting.

The best to work with is fine dentist's plaster, recently prepared and kept protected from the atmosphere. This will set in about ten minutes; but should the specimen be an old one, the splint may remain soft an hour or even longer. In an emergency very good work can be done with the common gypsum to be obtained of any plasterer, which should generally, before using, be freshly baked on a stove until moisture is no longer given off.

If it be desired to hurry the setting, the use of hot instead of cold water will do this. Also, the less water used, the quicker the hardening. Common table-salt dissolved in the water will also hasten matters, as would almost any crystalline substance. Either alum, silica, or cement-powder may be used, but salt, being the cheapest, is most commonly employed. I think that when salt has been freely employed, the splint, although setting quickly, is not quite as rigid as it would otherwise be. The use of dry heat will be referred to presently.

Setting may be retarded by the addition of starch, dextrine, glue, mucilage, gelatine, beer, milk, or borax; or by using plaster which has been exposed for some days to the air.

In regard to the material employed as a vehicle for the plaster, it is rather indifferent—any loose-textured fabric will do, and if properly made the splint will be sufficiently strong. For most purposes cheese-cloth or other gauze bandages, rubbed with dry plaster while being rolled, are best. These being stood in water, on end, until all the bubbles escape, are then, thoroughly wet, to be applied without reverses, which are here quite unnecessary. After from three to six thicknesses of such bandages, each thoroughly rubbed and smoothed with the hands before the next is applied, a final coating of dry plaster, dusted on and rubbed in as it moistens, leaves a surface

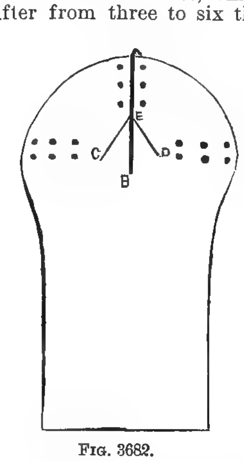

Fig. 3682.

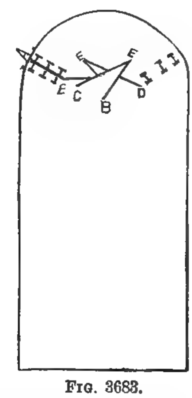

Fig. 3683.

Figs. 3682 and 3683.—Mill-board Model for a Shoulder-cap.

very smooth and even. If now the splint be hot-ironed with an ordinary flat-iron, or, as I have seen used, with a miniature stone garden-roller, the heat so applied drives off the superficial moisture, aids rapid setting, and leaves a rather glazed surface. This method of hastening the setting of the plaster is hardly worth the trouble it takes, except in the application of the plaster jacket to the body, in cases which do not bear kindly the partial suspension necessary.

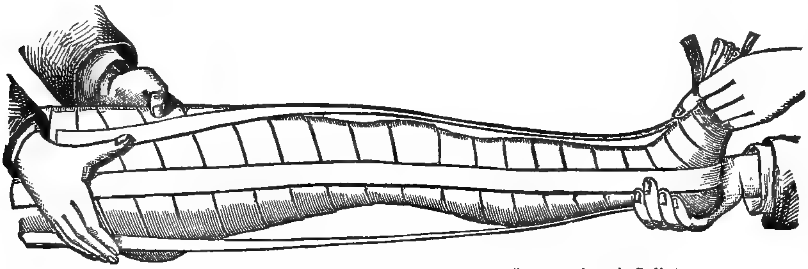

Fig. 3684.—Wooden Strips to be incorporated in a Plaster-of-Paris Splint.

To avoid the weight of a splint made as just described, we often employ stiffeners of various kinds placed between the bandages, and in lieu of some of them. For instance, thin wooden strips (Fig. 3684), or pieces of pasteboard, or strips of wire-gauze or of tin are used.

For field work, a readier means than that just given—unless gypsum rollers are at hand—is the Bavarian or book-back splint, or some modification of it. This is figured elsewhere (Fig. 1338, Vol. III.). It is sufficient, therefore, here to say that cloth, as, for example, a blanket of doubled thickness, has a straight seam sewn through both layers, which seam is so placed as to run along the back of the limb; plaster cream is spread thickly between these layers, and they are wrapped about the limb. When the splint has set it is opened in front, and the seam at the back acts as a hinge. The two halves are held in contact with the limb by straps or a roller.

A favorite method with the late Professor Little, of this city, was to cut several thicknesses of cotton-cloth or muslin the length of the splint desired, and not quite wide enough to meet in front at any point, so that an uncovered longitudinal strip of skin is left. These layers were then immersed and thoroughly soaked in plaster of the consistency of cream, and applied directly to the skin, which was either simply oiled, or, if hairy, shaven and oiled. A roller-bandage held the splint in place, and, after setting, this was cut away in front. Such a splint is easily sprung off, and on again. Gypsum splints possess considerably more of elasticity than would naturally be supposed.

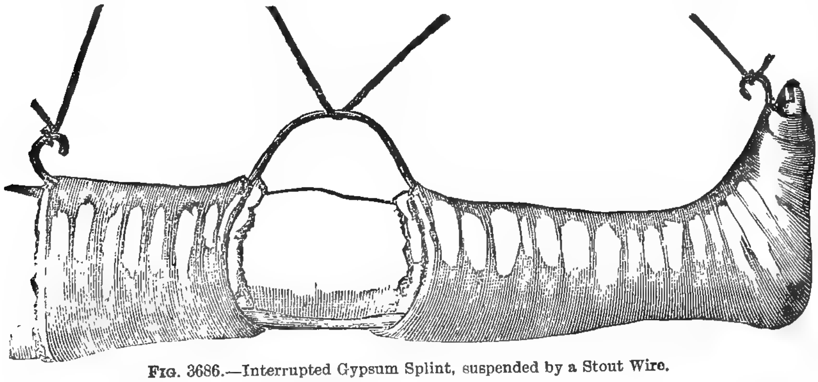

Fig. 3686.—Interrupted Gypsum Splint, suspended by a Stout Wire.

It is not usual to allow the gypsum to come into direct contact with the skin, as in the instance just mentioned. In the Bavarian splint the inner layer of blanket is the protection. When the ordinary method, with the plaster bandage, is the one adopted, it is best to cover the limb first with a flannel roller, or else with a layer or two of woollen, or several layers of cotton wadding—the latter being thinner than the woollen. *Wadding*, rather than *batting*, should be employed, the wadding being of uniform thickness. Whether flannel roller or wadding be our choice, it should be turned up over the ends of the plaster splint, in order to protect the flesh against a sharp edge.

If we wish to have our result appear extremely neat and workmanlike—certainly, next to the patient's safety and comfort, an object to be desired—we may wrap about the limb two strips of plush or velvet, each three or four inches wide—with the nap turned toward the skin—marking thus the upper and lower limits of our splint. The limb between these strips is to be covered as usual by flannel or wadding. The plaster roller then applied covers one-half the width of each strip, and, when the splint begins to harden, the strips are turned up over its ends, bringing the right side of the plush or velvet outermost.

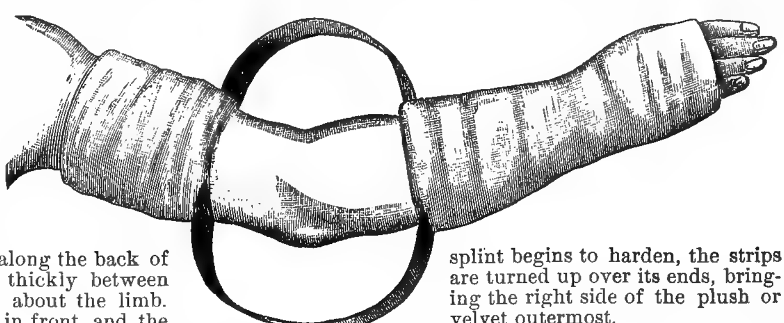

Fig. 3685.—Interrupted Gypsum Splint.

Gypsum splints made with an interruption are often used, as in compound injuries, or in excision of joints. Fig. 3685 shows such a splint, interrupted by ordinary hoop-irons embedded in the plaster, and sufficiently arched to allow the application of thick dressings between them. In Fig. 3686 is shown a similar splint, but suspended from a stout wire properly bent, and running along the front of the limb between the layers of plaster bandage. Here, in order to remove any possible danger of flexion, a posterior wooden splint is first applied, and over it the plaster.

When the presence of a compound fracture, or some other reason, compels the formation of a fenestra in the splint, this is best made as follows: Covering the wound, a saucer of the proper size for the fenestra is placed, bottom upward. Over this the usual plaster is applied, and when it has set the prominence made by the saucer easily enables one to cut out a circle of just the right size, at the right spot. This is better than using a wad here, being as sharply defined, and avoiding the pressure on the wound which the latter necessitates.

Fig. 3687 shows a fenestrated splint. It is a mistake, in a case requiring immobilization of the knee, not to carry the gypsum up nearly to the body. If the splint stops low in the thigh, as figured here, muscular action is more apt to break it.

If there be a discharge from the wound, or if moist dressings are to be applied, it is necessary to protect the edges of the fenestra, and prevent fluids trickling between them and the skin. By far the neatest means of accomplishing this is to cause a sheet of thin rubber—gutta-percha tissue—to adhere to the skin all around the wound on the one hand, and to the external surface of the splint on the other, by painting the skin and the splint with strong liquor gutta-perchæ (gutta-percha dissolved in chloroform).

In young children it is best to paint with an alcoholic solution of shellac a plaster splint which, from its position, would otherwise be liable to become softened and broken through repeated wetting with urine. Shellac, moreover, prevents the gypsum from rubbing off, and thus marking dark clothing.

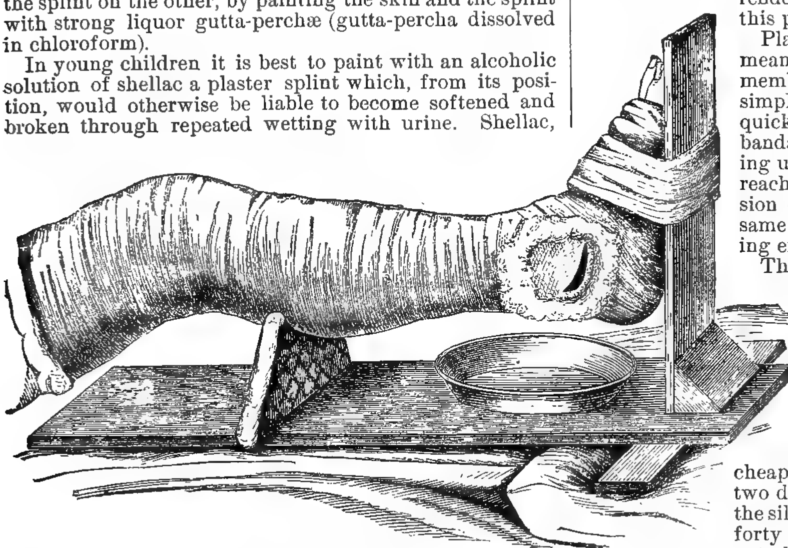

FIG. 3687.—Fenestrated Gypsum Splint.

The question how best to remove a plaster splint encircling either a member or the trunk, is a practically interesting one. The ordinary method is to endeavor to cut through it by the aid of a knife and much muscular effort. As a plaster dressing becomes about as hard as stone, such attempts are not soothing to the temper. The violent efforts made are also more or less dangerous to the patient, if the knife be not carefully guarded.

If the surgeon employs gypsum with some degree of frequency, it will repay him to procure the instruments shown in Figs. 3688 and 3689, or some modifications of them. The saw, on the plan of Hey's saw, will be valuable. The plaster shears selected should, like these, have a flat under-blade, great leverage, and an ample grasp for the hand, and should not, like Esmarch's, have scissor handles through which only a finger and thumb can be passed.

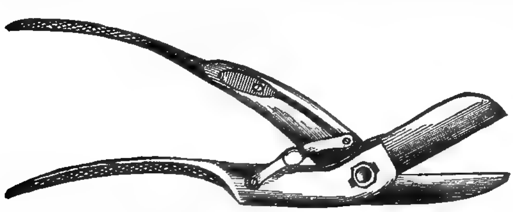

FIG. 3688.—Szymanowski's Plaster Shears.

For those who but semi-occasionally use plaster, there are other expedients which will lessen the fatigue. For instance, with a glass rod dipped in some strong acid capable of attacking the plaster—as nitric—draw a line where it is desired to make the section. With a cheap knife—for the acid will ruin it—cut along this line. Repeat the line of acid, and then the cutting, as often as needed. Each application of the acid will enable the cut to go a little deeper, without much effort.

Another method is to lay upon the splint cloths taken from boiling water, and repeat again and again. After a quarter of an hour of steady application the softened splint may be cut with moderate ease.

Still another expedient: Soak a narrow strip of cloth, or a piece of tape, in sweet-oil, and place it along the limb, upon the wadding or other subdressing, at the line to be subsequently cut. Then apply, over strip and all, the gypsum dressing. It will be found that the oil renders the plaster somewhat softer at this point than elsewhere.

Plaster splints, however, do not by any means necessarily always encircle the member. Their shapes are legion. A simple straight splint, for instance, is quickly made by running the wet plaster bandage up and down the limb, repeating until a sufficiently great strength is reached. An anterior splint for suspension can be fashioned with ease in the same way, wire loops for the tackle being embedded at proper intervals, etc.

The silicates ("water-glass") as a plastic agent have the advantage of extreme lightness of the splint, when hard; but hardening requires a long time—nearly three days with silicate of soda, which is cheaper than that of potash; two days with a mixture of the silicates; about thirty to forty hours with silicate of potash; and less than a day if some substance, such as magnesia, chalk, slaked lime, or cement be freely mixed with the solution, making it of a consistency like that of honey. In this way it will dry more quickly than a starch bandage, though, of course, not nearly so rapidly as gypsum.

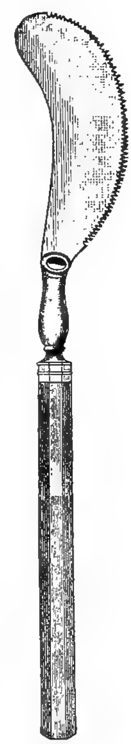

FIG. 3689.—Plaster Saw.

A saturated solution of the silicate desired is made, and bandages or other material are soaked in this, and applied just as with plaster. It is very sticky, and hence more disagreeable to manipulate than the latter. The solution should be freshly prepared, as, if old, it is capable of irritating the skin quite severely. When the splint is in place, a final brushing with alcohol will leave a surface of almost glassy smoothness.

It is, of course, essential that the limb be held rigid while setting is going on, and therefore a temporary wooden splint over the water-glass is needed. If a jacket for the body be desired, some surgeons have advocated covering the silicate splint with one of plaster-of-Paris, the latter to be cut off and removed later, when the water-glass splint beneath has hardened. This seems to the writer unnecessary trouble, as a simple plaster jacket can, by the aid of stiffening strips, be made to combine lightness with strength. The water-glass jacket may be cut like that of gypsum, and held together with straps or lacings.

Most of the remaining plastic materials are hardly worthy of detailed notice as a first choice, because of relative expense, of too prolonged or too brief a period of setting, or of various other objections.

Starch is sometimes employed, made by stirring with cold and then adding boiling water. The thick mucilage resulting is either brushed on layer after layer of applied bandage, or the fabric used is first soaked with it and then applied. This makes a light, cheap dressing, but hardens slowly—in thirty to forty hours—and contracts somewhat. Flour paste, or white of egg and flour, may be used as a substitute.

Dextrine—"British Gum"—is made by adding dilute

sulphuric acid to starch at boiling-point. It is dissolved in as little alcohol as possible, plus a little water. Camphor added seems to aid hardening. Apply as with starch.

Thick glue, to which alcohol is added to promote more rapid drying; glue or mucilage and chalk—as, equal parts of gum arabic and precipitated chalk; or glue and zinc oxide, will effectually stiffen the material with which they are impregnated. The second mixture hardens more rapidly than starch, requiring from four to five hours. The third sets still more quickly, though quite slowly as compared with gypsum. Too great a proportion of oxide of zinc should be avoided, as it renders the splint brittle.

Gutta-percha makes an excellent but rather expensive splint. That it is not sufficiently porous is an objection urged against it, in common with several others of this group. A sub-dressing is always used, and this objection seems to me, therefore, unimportant. The gutta-percha should be softened by immersion in *warm*, not *hot*, water. If the latter is used, the outside will become very soft and adhere to everything it touches, before the rest is affected by the heat. When warmed through and softened so as to be workable, it may be made flat and of any desired thickness, by means of a wet rolling-pin on a wet board. Then soften again and instantly apply. It sets almost at once, requiring rapid work.

Tripolith is a substance which also sets very rapidly—too rapidly, in fact. It is a gray powder, of lime, silicon, and iron oxide—not so heavy as gypsum, and is manipulated by the same methods as the latter.

Either paraffin or stearin may be used, melted and painted freely on the bandaged limb with a brush. Such splints are not quite as rigid in midsummer as in cold weather. In removing them, a hot blade aids the cutting.

In an emergency, clay moistened and rubbed thickly into and upon the meshes of the roller, or other sub-dressing, will do. As with many of the dressings already described, the application of dry heat about the finished splints—as by hot bricks, or bottles filled with boiling water—will aid evaporation and shorten the tedious hardening process.

Shellac cloth—as several layers of cotton cloth soaked in a saturated solution of shellac in alcohol and pressed together into a solid whole—may be obtained ready prepared; it makes a very desirable splint, and one which is rendered perfectly plastic by immersion in hot water, and afterward sets moderately quickly. As compared with a gypsum splint, it is, of course, more expensive.

A similar dressing may easily be extemporized, if desired, by soaking sheets of blotting- or wrapping-paper, or thin cloth in the shellac solution just mentioned, or in collodion. In a case of Pott's disease recently published, the operator, Dr. Taylor—not having gypsum or any splint material other than this at hand—first made a mould of the back with shellac blotting-paper, and when this mould had hardened, added to it alternate layers of fresh shellac blotters and glued coarse linen, until sufficient resisting power had been produced.

As a splint, adhesive plaster is only in one sense properly a member of this group. It does not "set." It is not much harder when cold than when warm, being easily flexible at all times. But in several instances it has been advocated as a splint, notably in Pilcher's method of treating Colles' fracture, which consists in supporting the fragments after reduction by wrapping a number of times about the wrist a narrow strip of adhesive plaster, until the splint is about two inches wide and moderately stiff and firm. Rubber plaster is rather too soft for this purpose.

This is only one among scores of different devices for the cure of this particular bone-lesion. It seems to the writer that it is rather a trivial matter which splint be chosen in Colles' fracture, and not worthy the numerous volumes which have been devoted to it. If the fragments have been disengaged and restored to good position, any splint which will keep them quiet is the right one. If the fragments have not been properly reduced, no splint will do this, and deformity will be inevitable.

In concluding this article, it is hardly necessary to say that much of the subject-matter is as old as Surgery, and for the rest the writer is largely indebted to very many authors well known in their specialty.

Robert H. M. Dawbarn.

SPONGE (*Éponge fine*, Codex Med.). The household articles known by this name are the horny or silky skeletons of several species of invertebrate animals belonging to the Order *Ceratosa*, in the great Group *Parazoa* or *Spongiæ*. The commercial sponges are colonial in their composition, although the outlines of individuality are very obscure. They are soft, porous, gelatinous bodies, perforated by numerous openings communicating with irregular, ramifying cavities within them, as well as with digestive and respiratory chambers, and more or less regular tubes or canals. These minute chambers are lined with flagellated cells, which are probably the organs of nutrition as well as those by whose movements a constant stream of water is kept flowing into the sponge through the fine pores and out through the larger openings. Sponges are all aquatic, and those of commerce all of marine origin, growing upon rocks or other firm foundation, at a depth of from six to a hundred or more feet below the surface of the water. They are of slow growth, requiring from three to six years to attain a useful size. The mode of collection varies with the depth at which they are found as well as with the habit and outfit of the collector; sometimes they are torn off the rocks by tongs or hooks, sometimes dredged for, but more generally they are gathered by divers from boats; these again may go down unprotected for three or four minutes at a time, or, equipped with modern diving-suits, make longer and deeper searches. Finally, the cultivation of sponges by fastening bits upon boards or sticks, and then sinking them to the bottom, has been proved practicable. When the sponges have been brought to land they are rubbed with sand or bruised to break up the soft parts, or exposed to the air until decomposition sets in, and then repeatedly washed and squeezed until they are clean. They are then dried and sent to market, where they are carefully trimmed and assorted, according to kind, fineness, size, and shape, into numerous grades.

There are several distinct kinds, dependent upon the species producing them:

1. The *Levant* or *Turkey Sponge*, from *Euspongia* (*Spongia*) *officinalis* Linn., the finest and most expensive of all, from the waters surrounding the Grecian Islands, Asia Minor, Syria, etc. It has a soft, fine, very elastic texture, a light color, and great toughness of fibre. In shape it is rounded, tuberculated, lobed, hemispherical, cup-shaped, or irregular: it is very free from its gelatinous flesh when prepared for the market.

2. The *Zimocca Sponge*, from *Euspongia Zimocca* O. Schmidt; also a fine, strong, valuable sponge, but harsher to the feeling than the preceding, and not nearly so expensive.

3. The *Mediterranean Bath Sponge*, from *Hippospongia equina* O. Schmidt; in large, soft, rounded masses, with a loose texture and very large reticulating canals.

Besides these, this country is supplied in great abundance with very cheap sponges from the West Indies; they are much inferior in texture and durability to the Mediterranean products: they are,

4. The *Reef Sponge*, *Euspongia officinalis*, var. *tubulifera*, is the common cheap, fine "slate sponge," it is coarser, less elastic, and very much more tender than the Turkey sponge, and is of more or less conical shape, with a broad, cut base.

5. The *Sheepswool*, *Velvet*, and *Grass Sponges*, from various species of *Hippospongia*.

Composition.—Sponges contain a considerable quantity of fine sand, and sometimes pebbles, entangled in their meshes, which can generally be removed by mechanical means; there is also a varying amount of calcareous concretions or fragments, which stick more tenaciously and often have to be dissolved by dilute acid. These being removed, the remainder is nearly all a peculiar elastic, durable, nitrogeneous substance called *Spongin*, closely

related in composition and texture to silk. Besides this, there are a little iodine, bromine, salt, etc.

USES.—These are mostly mechanical or household, and familiar to everyone. Carbonized sponge, *Spongia usta*, now obsolete, used to be given for the same conditions for which iodide of potassium is now used, and owed its value to the presence of that element.

In surgery sponges have long been used for packing and dilating cavities, and as absorbers of blood in operations. The general acceptance of antiseptic methods in surgery has caused them to be looked upon less favorably than formerly, and requires a special preparation before they are to be used at all. For surgical operations the fine, soft, Turkey sponges, though dear, are the best. With care in washing and sterilizing, in private practice they may be used repeatedly, and so their first cost made less of an objection, or the fine West India sponges may be used once and thrown away. The bath and sheepswool varieties are too porous and soft to be of any use as blood-absorbers. A sponge of a size convenient for the hand and operation, and of a rounded shape, without large canals or deep constrictions, should be selected. They may be bought already bleached or, better, unbleached, and bleached by the surgeon, who should always superintend the sterilizing and preservation of them. They may be bleached by a chlorine solution, being carefully watched, and removed before they have acquired a bright, golden-yellow hue; it is, however, a poor method, and apt to rot them. Dilute sulphurous acid or a bromine solution is better, but perhaps the best method of all, for surgical use, is that by means of permanganate of potash and oxalic acid, as follows: After beating and shaking, or dissolving out all mineral impurities, soak the sponges in a strong (say, one per cent.) solution of permanganate of potassium, then rinse them and wash in a solution of oxalic acid, strong enough to taste sharply sour, stirring and pressing them until the color of the permanganate is entirely discharged; then wash very thoroughly with clean water. If they are not white enough, repeat the whole process again, but do not leave the sponges longer than necessary in the acid. They are then bleached, but not sterilized; for the latter purpose soak them for an hour or more in a five per cent. solution of carbolic acid, to kill active organisms; wash in clean water until the carbolic acid is removed, then set in a pail of water in a warm place for twenty-four hours in order to germinate the spores, and finally put again in five per cent. solution of carbolic acid. They may be kept in this solution, renewing it occasionally, until needed, or they may be pretty safely put in a sterilized bag of several thicknesses of close cotton cloth and kept dry until wanted. Corrosive sublimate injures sponges very quickly, alcohol shrinks them and temporarily destroys their elasticity, hot water damages them permanently, and alkalies or strong soap-solutions dissolve them. After having been used, the cleansing and sterilizing process is to be repeated in full.

Sponge tents, now but little used, are made by soaking fine, tough sponge in melted cocoa-butter, or in mucilage or alcohol, and winding very hard to cylindrical shape with strong twine; when dry or cold the cord is removed and the surface is filed or pared to shape.

Ether sponges are fine Turkey sponges of large size, requisite fineness, and of a regular cup-shape. No inhaler has yet been made so safe or comfortable to the patient as these, but they are wasteful of ether. *W. P. Bolles.*

SPONGE-GRAFTING. The recent introduction of sponge-grafting as a means of promoting the repair of chronic ulcers and other solutions of continuity rebellious to ordinary treatment, has proved of such service in the hands of those who have resorted to it, that we cannot too urgently advocate its claim to the attention of the surgeon. We are indebted to D. J. Hamilton, the distinguished Professor of Pathological Anatomy, Aberdeen University, for the introduction of this material for the cure of ulcers.

That we do not here exaggerate the value to be attached to sponge-grafting, the relation of the following case, occurring in the writer's practice some time since, amply demonstrates. This case presented itself just at the time when the writer was in receipt of a letter, accompanied by a package of sponge, from Professor Hamilton, and it was determined to make a practical test of the method at once. Pieces of these sponges were adjusted to nearly every portion of the ulcerated area, covered with oil-silk, and daily cleansed with carbolized water. When it became necessary to remove any piece of sponge which had not remained aseptic, the bare spot was at once covered with a fresh piece. This treatment, persevered in for one month, brought about a gradual development of granulations, and finally resulted in a perfect cicatrization of the ulcer. It is worthy of note that this case had been under treatment for a very long time, and the presence of the offensive discharge had evidently influenced the general health of the patient; but notwithstanding this, and the fact that the area of ulceration was so extensive, the wound healed promptly under this treatment. It is equally of importance to state that there has been but little contraction of the cicatricial tissue, though several years have now elapsed since recovery.

In almost every hospital ward the surgeon is confronted with a class of ulcers that persistently resist all attempts to promote their healing. Repair can take place only through a healthy granulating process, and when cicatrization is postponed the cause must be referred to some abnormal condition of the granulations. The several forms of diseased granulations, whether fungous, hæmorrhagic, croupous, or diphtheritic, may be rendered healthy by well-directed treatment. But it often happens that, in the absence of any specially diseased state of the granulations, unless it be the want of nutritive power to sustain themselves, their functional activity becomes too soon exhausted, and, in consequence, the process of cicatrization is delayed. In this state of relaxation and collapse, all granular appearance disappears, cell-proliferation ceases, pus-cells no longer emigrate, the vascular loops droop, fall over, become thrombosed, degenerate, and disintegrate; and this morbid process is repeated as often as the pressure from below forces other vascular loops to the surface. To offer these weak and disorganized granulations a surface support through contact with some more vitally endowed tissue, is the indication which naturally suggests itself, and which might well have been fulfilled at the time when John Hunter showed the possibility of grafting living tissue upon a denuded surface, when he transplanted the cock's spur upon the stump of its comb. It was, however, reserved for Reverdin, only a few years since, first to put into practice his method of skin-grafting. However productive of the best results this method has often proved to be, yet, it must be confessed that skin-grafting is neither agreeable, expeditious, nor always available. The application of sponge-grafting, on the contrary, as a ready means of cure—for the material is always at hand and can be easily prepared—presents an interesting subject of contemplation to the histologist as well as to the pathologist in the mode by which it accomplishes this end.

It is well known that a living tissue may take root, become nourished, grow, and cover an abraded surface with which it is retained in contact; but the interest attached to the sponge in this connection is of a very different nature, for we are here making use of a material which is neither organized nor living. The question arises, in what way does such a material promote rather than, as a foreign body, impede, cicatrization? Looking critically into this subject, in order to offer a demonstrative explanation of the agency of the sponge in securing, maintaining, and assisting in such a process, we must first consider the mode in which organization takes place in a blood-clot.

It was formerly believed by most physiologists that the coagulation of blood was a proof of its vitality. The clotting of fibrin and its subsequent fibrillation was supposed to be a spontaneous assumption of structure, since there is a felt-like, matted arrangement of decussating

fibres, wholly unlike the granular and homogeneous particles of coagulated albumen, through and among which blood-vessels appeared to be developed *de novo*. But a closer examination has shown the fallacy of this view. The clotting of fibrin is now known to be an evidence of the death, not of the life, of the blood. Within the interspaces of this fibrillated stratum loops of blood-vessels are projected from the deeper-seated structures, while leucocytes and blood-corpuscles are entangled within its meshes; whatever vitality these corpuscles at first possess is very soon lost; degenerated and destroyed, they finally disappear with such few blood-disks as may at first be found in the clot. The underlying, distended, and tortuous blood-vessels are displaced and pushed out farther into the clot, carrying with them connective-tissue corpuscles which, proliferating, insinuate themselves as broods of cells into the interfibrillar spaces. The fibrinous network now contracts, expresses all of the serum therein contained, begins to fall to pieces, and finally itself disappears; and all of this is coincidently connected with the destruction, through fatty or granular change, of both orders of blood-cells. There seems, therefore, to be no evidence to support the views of Cohnheim and others, that a blood-leucocyte is converted into fibrous tissue. The subsequent cicatricial or fibrous tissue owes its origin, not to these corpuscles which disappear, nor again to the original fibrin-clot, which also is sooner or later removed; for it is known that the fibrous tissue ultimately formed into cicatricial structure, is not that first seen in the blood-clot—the original fibrinous material which the extravasated blood furnished—but newly-formed fibrous tissue evolved through the morphological changes of the connective-tissue corpuscles. So far, then, as the original clot was concerned, it may be said to have been perfectly *passive*, having, through its elastic and porous arrangement of fibres, served the purpose of a trellis-work, supporting the growing cicatricial tissue. The embryonal cells may actually be seen to elongate into spindle-cells that are slowly transformed into the fibrous tissue which forms the cicatrix.

Another point of interest and worthy of careful study, is the mode by which the vascularization of the new tissue is established. According to many writers, this is accomplished by the actual development of newly-formed blood-channels, but, notwithstanding the scientific authorities who support this view, Professor Hamilton has never been able to verify the production of new vessels; in no instance did he discover anything but loops of ready-formed vessels, the convex side of these being invariably directed toward the distal or peripheral parts, the concave toward the proximal; and he detected none of these vessels ending in free extremities. There was always a complete afferent and efferent vessel. "When such a loop reached the sponge framework," he says, "it was pushed into it, often some distance in advance of the cicatricial elements which usually surrounded these vessels. It still, however, maintained the character of a complete capillary loop, and I was unable to detect anything like a free, newly-formed, and pointed offshoot on examining other portions of these vessels for any evidence of sprouts from their sides; I must say I could not detect anything of the kind. . . . Another curious point—if these vessels were newly formed—was that the stems leading up to the capillary loops at the edge of the cicatricial layer possessed, in many cases, a completely formed adventitious coat . . . the appearance of fully developed capillaries, without any evidence of offshoots branching from them."

From this investigation of nature's method of organization of the blood-clot, we learn that the fibrin fulfils the passive purpose of a framework for the support of vessels, not of new formation, but of such as are forced into it from subjacent parts, surrounded by connective-tissue corpuscles, whose polynucleation and subsequent germination eventuate in a progeny of new cells, migrating into every interspace, aggregated into clusters which press destructively upon each and every fibrillar shred of the network, and finally constitute themselves the progenitors of the incipient cicatricial tissue.

Now, let us compare this process in the blood-clot with that taking place in the sponge, when used in the manner which we shall describe. Sponge closely resembles in its porous nature the trellis-work of a fibrillated blood coagulum, when through the proper method of preparation it has been converted into fine layers or sheets of extraordinary delicacy. If such a piece of sponge, properly prepared and rendered aseptic, be adjusted to an ulcerated surface, the feeble granulation loops of which need support, we can readily imagine that the subjacent capillaries will push themselves into its interstices, just as we see them do in a blood-clot. This organic connection, which the sponge contracts with adjacent and easily denuded surfaces, has indeed often been seen, and sometimes seriously realized, when, for example, a sponge-tent has been incautiously left too long imprisoned within the cervix uteri. Who has not met with difficulty in its removal, which has only been accomplished at the expense of a laceration of vessels that have penetrated the very meshes of the sponge, and which often is accompanied with considerable hæmorrhage?

These capillaries are under no restraining influence upon denuded surfaces, and are naturally forced out into loop-like processes under the constant blood-pressure derived from each propulsive action of the heart, to such an extent indeed, in all granulating wounds, that they often must be compressed or "kept under" by remedial agents daily applied to such exuberant granulations. It sometimes happens that these blood-vessels grow to such lengths that they fall over, their circulation becomes obstructed, and thus they fail to fulfil their purpose in wound repair. If, in such a case, the wicker-work of a sponge be placed so as to support the loops, they may then climb to the surface and establish a degree of vascularization which carries with it connective-tissue corpuscles from neighboring parts, out of which in time a true cicatricial structure may be formed. It is thus that sponge-grafting has been discovered to supplement, as it were, a natural process, and, on microscopical examination, is seen to bear the relation to neighboring parts which we have endeavored to demonstrate. It is needless to state that, as cicatrization advances, the new elements of reconstruction are found to press upon the meshes of the sponge, which, like the fibres of a clot, slowly disintegrate and are removed. During the entire progress of the changes that are seen in parts thus undergoing advancing cicatrization, the sponge texture becomes so infiltrated with tissue-corpuscles and filled to repletion with reticulated, convoluted, and looped vessels—in other words, so thoroughly vascularized—that it appears to the unaided eye to be actually organized; and it even bleeds at the touch, or when it is pricked by the finest pointed needle. Holding, as it were, upon a scaffold the elements of repair, while they are actually being converted into veritable tissue, the sponge seems to fulfil another important purpose, for it certainly thus prevents, or at least diminishes, the subsequent shrivelling of the cicatrix. This was well seen in the case above cited.

It only remains to state that this sponge must be rendered aseptic, and should, of course, be first deprived of all extraneous particles. It should be immersed in some weak acid to destroy every particle of inorganic material, after which it must be washed in liquor potassæ, perfectly cleansed again in distilled water; it is to remain for some days in a strong solution of carbolic acid, then dried, when it can be cut with a section-cutter into delicate layers, which may be kept ready for use, wrapped in oil-silk.

Middleton Michel.

SPRING LAKE MAGNETIC SPRING. *Location and Post-office*, Spring Lake, Ottawa County, Mich.

Access.—From Chicago by the West Michigan Railroad to Ferrysburg, less than a mile from Spring Lake; or by boat to Grand Haven, thence by Detroit, Grand Haven & Milwaukee Railway to Spring Lake; from Detroit by the Detroit, Grand Haven & Milwaukee Railroad.

ANALYSIS.—(Professor C. G. Wheeler). One gallon contains (50° F.):

	Grains.
Chloride of potassium	4.2880
Chloride of sodium	405.5330
Chloride of calcium	113.4200
Chloride of magnesium	36.2000
Chloride of sodium	0.9537
Bicarbonate of calcium	0.1808
Bicarbonate of iron	1.0060
Bicarbonate of magnesium	0.0640
Bicarbonate of manganese	0.0647
Bromide of magnesium	2.1700
Sulphate of sodium	46.7000
Silica	0.5030
Alumina	traces
Ammonia	0.0158
Organic matter	18.2702
Lithia	traces
Total	629.5692

THERAPEUTIC PROPERTIES.—This is a valuable saline water, containing an appreciable quantity of the bromide of magnesium. The claim to magnetism, which this and other springs in Michigan boast of, is not borne out by scientific investigation. This property is found to be due to, and to reside in, the iron tubing.

The waters are employed as a cathartic in diseases of the liver and digestive organs.

This spring is located in the town of Spring Lake (1,500 inhabitants), on a beautiful sheet of water of the same name. It is three miles east of Grand Haven, on Lake Michigan. The lake empties into Grand River, which forms the harbor of Grand Haven, and affords delightful boating and excellent fishing. There are several good hotels, provided with all the modern improvements necessary for comfort. There are also good facilities for bathing. *G. B. F.*

SPUNK (*Fungus Chirurgorum*, Ph. G.; *Agaric de Chêne*, Codex Med.; *Amadou*, etc.). A preparation made from *Polyporus fomentarius*, or *P. igniarius* Fries; Order, *Basidiomycetes* (*Fungi*).

Both the above fungi are parasitic upon the trunks of forest-trees, especially of oaks and beeches. They are attached by broad bases and expand horizontally in large, rounded, hoof-shaped masses of corky texture, and reddish- or grayish-brown color; the upper surface is convex and marked by a series of distinct concentric rings, each of which indicates a year's growth. The underside (hymenium) is flat. *P. igniarius* is a little flatter, rather smaller, and in an early stage more velvety upon the surface than the other; otherwise they are very similar. Both the above species are collected, as well as a few others, for making surgeons' styptic fungus or amadou; but *P. fomentarius* is said to yield the best quality.

For surgical use the middle portion only is taken, the top and bottom layers being cut away, and, after being softened in water, it is beaten with a wooden mallet into a tough, flexible, buckskin-like sheet, and dried. In this condition it will absorb more than twice its weight of water. It was formerly used to stop bleeding, by being packed or bound over the bleeding surface.

Spunk, properly so called, or tinder, consists of this "amadou," prepared as above and soaked in a solution of nitre or chlorate of potassium. It is very inflammable, burning without flame, but scintillating now and then, and holding fire for a long time. This, which is sometimes kept in the shops, can be prepared for surgical use by dissolving out the saltpetre in water, and drying. The blood-stanching action of amadou is entirely mechanical, and it is almost completely superseded by the excellent preparations of absorbent or styptic cotton, or by lint, "spongio-pilin," etc., with which the market is supplied.

ALLIED PLANTS, ETC.—See AGARIC, PURGING.

ALLIED SUBSTANCES.—Cotton, lint, charpie, and sponge are used now for the purposes for which amadou was formerly valued. See also MATICO. *W. P. Bolles.*

SQUILL (*Scilla*, U. S. Ph., Br. Ph.; *Bulbus Scillæ*, Ph. G.; *Scille*, Codex Med.). The bulb of *Urginea maritima* Baker (*Scilla maritima*, Linn.); Order, *Liliaceæ;* a perennial herb with an onion-like bulb, liliaceous leaves, and a long spike of regular, small, hexamerous flowers.

FIG. 3690.—Scilla Maritima; bulb and leaves. (Baillon.)

The bulb is large, four or five inches long, globular, covered with two or three dry reddish or gray papery scales, and made up within of numerous thick fleshy ones. The greenish-white flowers appear in the fall upon a scape one or two feet long, and form a spike nearly as long as the scape; perianth, six-parted; stamens, six; ovary, three-celled; seeds, fifteen or twenty, winged; leaves, vernal, narrowly lanceolate, one or two feet long.

Squill grows mostly, as its name indicates, not far from the sea-shore in dry, sandy places. It is native to nearly the whole Mediterranean coast, and is especially common in Spain. There are two varieties, the white and red, distinguished by the color of the outer tunics of the bulbs.

For medicinal use the bulbs are collected in the latter part of summer, the outer scales peeled, and the rest sliced transversely in slices from an eighth to a quarter of an inch thick, and dried in the sun.

It is then in quadrangular strips, two sides of which are covered with cuticle, the remaining two being sections; the strips are curved and shrivelled, of a whitish color, brittle if very dry, but hygroscopic and generally somewhat flexible, nearly odorless, and having a mucilaginous taste, becoming bitter and acrid. It consists of a simple parenchymatous tissue loaded with mucilage containing numerous oxalate of lime crystals, and traversed by occasional vascular bundles.

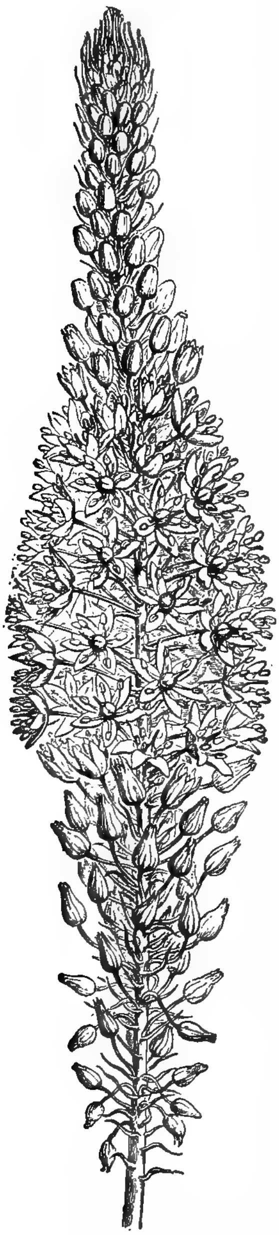

FIG. 3691.—Scilla Maritima: Inflorescence. (Baillon.)

Few medicines outrank Squill in antiquity; it is mentioned by nearly all writers upon medicine, from the earliest down.

COMPOSITION. — Besides the mucilage and some sugar and the oxalic salts, Squill contains a dextrin-like substance called *Sinistrin*, of no active properties. The principal ingredients are, a bitter, active principle, *Scillitoxin*, amorphous, light-brown, soluble in alcohol, not in ether or water, a cardiac poison resembling digitalis; *Scillipikrin*, a yellowish white, amorphous, hygroscopic powder, similar to the above but less active; and finally *Scillin*, of no medicinal qualities.

ACTION AND USE.—Squill has in a measure the heart-slowing and diuretic action of digitalis, for which it is occasionally substituted—with which it is more frequently given as an adjuvant. As a slightly depressing expectorant it is a common ingredient of cough-preparations. Large doses (from 6 to 12 grains) occasion vomiting and purging.

ADMINISTRATION.—Squill is difficult to powder, apt to cake up when powdered, and seldom given in substance.

The following preparations are officinal: Fluid Extract (*Extractum Scillæ Fluidum*, strength, $\frac{1}{1}$), dose, one to two minims; Tincture (*Tinctura Scillæ*, strength, $\frac{15}{100}$), 8 to 24 minims; Vinegar *Acetum Scillæ*, strength, $\frac{1}{10}$), 15 to 60 minims; Syrup of Squills (*Syrupus Scillæ*), dose, 4–8 c.c. (ʒ j.—ʒ ij.). The Compound Syrup (*Syrupus Scillæ Compositus*) is rather a preparation of antimony than of Squill.

ALLIED PLANTS.—The Genera *Allium*, *Scilla*, *Drimia*, etc., are closely related to Squill and some of their species are sometimes substituted for it.

Onions and their relatives are members of the same Group.

The Order *Liliaceæ* is a very large one, furnishing many beautiful garden and greenhouse flowers, and a few useful food-plants. It is in general, however, poisonous or suspicious.

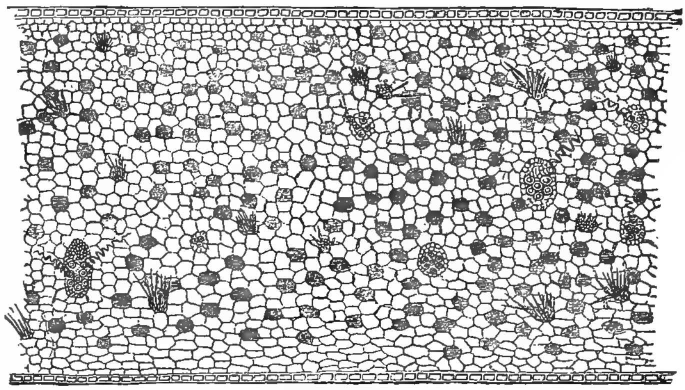

FIG. 3692.—Squill: transverse section of a Scale, magnified. (Baillon.)

The following are the most important medicines produced by this Order:

Allium sativum Linn....................Garlic.
Aloë, sp. var............................Aloes.
Veratrum viride ....American Hellebore.
Schoenocaulon officinale (*Asagræa*) ....Sabadilla.
Colchicum autumnale Linn ....Colchicum.
Etc., etc.

W. P. Bolles.

STAMMERING. Synonyms: *Lalling, Dysarthria Literalis, Stammeln, Balbutiement.* Stammering is defined as imperfect articulation of the vowel or consonant sounds, due to malformation of the organs of speech, or to imperfect innervation of the muscles employed in articulation.

Articulate speech is formed by a column of air set in vibration by means of the vocal cords in the larynx, and interrupted and varied in pitch and quality by the mouth and nasal cavity. In order to bring about these variations the tongue, lips, and palate are moved, so as alternately to open and close the passages, and in this way a very large number of sounds may be produced, which are represented by letters and called vowels and consonants. Only a small proportion of the possible sounds is used in any one language.

A continuous sound made with the air-passage open is called a vowel. The particular vowel produced depends on the position and degree of approximation of the parts during phonation.

Consonants are made with the passages more or less closed. Some of them are capable of indefinite prolongation, the air escaping either through the nose, as with *m* and *n*, or between the tongue and palate, as with *l*, *r*, and *s*. The explosives *b*, *d*, *g*, *k*, *p*, and *t*, cannot be prolonged, but there is a preliminary sound called a burr while the air is passing into the pharynx and mouth, and then the passage is opened with a flap, and takes the position of the following vowel.

No sharp line can be drawn between the two classes. The consonants *w* and *y* are made in the same way as the vowels *o* and *e*, with only a little closer approximation respectively of the lips, and of the tongue and hard palate.

Consonants are joined with the preceding and following vowel sounds. Stammering has nothing to do with the joining together of sounds, but is the inability to render them properly, even when given alone. The terms stammering and stuttering are confused, always in the older writings, often in more recent ones. The difference between them was discovered early in the present

century. Stuttering, as we shall see, is characterized by attacks of spasm varying in severity, but always of the same nature. The stutterer can render the separate sounds perfectly under favorable conditions. His trouble is only occasional, and brought on usually by the attempt to pronounce one of the explosives mentioned above.

On the other hand, stammering must be distinguished from aphasia. That has to do with neither the production nor the joining together of sounds, but with the construction of syllables and words as a whole. It is caused by the disabling of those parts of the cerebral cortex which contain the sensory or motor speech memories, or of the fibres connecting these with other parts of the nervous system.

The highest point in the cerebrum at which a lesion can cause a purely literal defect, is at the level of the corpora striata.[1] Disease above this causes impairment of the power of perception or construction of words or syllables.

Aside from occasional faulty pronunciation, to which everyone is more or less liable, there are many cases of stammering in which the trouble is due to sheer carelessness and inattention, fixed by habit. These cases are important as well from a diagnostic as from an educational standpoint, as they may be mistaken for cases of acquired speech defect, especially when organic brain disease coexists with them.

The capability of pronouncing different sounds is a matter largely of race and training. Everyone stammers in a foreign language, if he undertakes to learn its new sounds after his habits of speech are formed. Thus the German *ch*, French nasals, and Italian *r* are seldom perfectly acquired by an adult. But, according to Kussmaul, "the most choking guttural of a Swiss throat modestly retires before the vomiting throat-sounds of an Arabian."

We may divide our subject into stammering from: 1. Habit or carelessness. 2. Organic defect of the organs of speech. 3. Disease of the nerve-centres. The speech defects in all these cases may be identical, and in order to distinguish them one from the other a careful examination and attention to the history are often necessary. A complete list of sounds which may be mispronounced is not possible. It will be sufficient to indicate a few of the more common ones.

The mispronunciation of the letter *r* is called Rhotacism or Burring. This letter has the same general sound, but is produced in various ways by different nations. In English-speaking countries it is formed by approximating the sides of the tongue to the roof of the mouth, but in certain localities is often slurred. Its place is then taken by a *ŭ* or *ä* sound. In southern England it is produced by the tip of the reverted tongue. In Italy it is made by a rather prolonged and rapid vibration of the tip of the direct tongue against the palate. The Italian nobility profess to be unable to produce this sound, and use the English *r*. In Northern Germany it is made by the uvula, in Sweden by the glottis. It is evident that correct speech in one country is stammering in another; *e.g.*, the use of the uvula in pronouncing the English or Italian *r*. Again, the ordinary sound may be replaced by an entirely different one. In this case *l* or *w* is usually employed. This is regularly done by children, who acquire the *r* sound among the last.

L is often mispronounced—*r*, *d*, *t*, *y*, etc., being used instead. This is called Lambdacism. *L* should be made by placing the tip of the tongue against the hard palate, and then phonating so as to make a continuous sound, the air escaping at the sides of the tongue. If the air does not escape, the explosive *d* is produced instead; if the tongue does not touch the palate, the half-vowel *y* is made, and so on.

Lisping, or Sigmatism, is the most common form of stammering. It consists in giving *s* a wrong sound, usually that of *th*, by carrying the tip of the tongue too far forward, so as to touch the upper teeth. In this way both the hard and soft sounds of *s* are replaced. This occurs even among the Germans, who have no *th* sound in their language.

Gammacism is the mispronunciation of the letter *g*. It is sometimes hardened into *k*, sometimes changed to *d*, especially by children.

Examples of the mispronunciation of consonants might be multiplied indefinitely. Whole classes of them are changed in definite ways by different nations in learning foreign languages, so as sometimes to constitute a dialect, *e.g.*, the Scotch and Irish brogues; and, in fact, we may bring under this head many provincialisms, among them the cockney misplacing of the aspirate.

Stammering of vowel sounds consists in slurring them, so that they lose more or less of their individual character. A certain degree of this is in conformity with the spirit of the English language; in fact, many of our different vowels are, under certain circumstances, rendered in exactly the same way, *e.g.*, in bird, burn, and father, and in bun and monkey. When carried beyond the degree sanctioned by general usage, this is stammering.

Hesitating speech with interpolation of a *ŭ* sound is popularly called stammering, but usually is simply a device for gaining time.

1. All the above varieties, although they may be produced by organic causes, are often simply the result of habit. Examination then shows that the patient has always spoken in the same way, and reveals absence of other symptoms of disease; but it should be borne in mind that stammering may coexist with any disease which is compatible with speech.

Treatment here is simply an education. The patient should be carefully shown how properly to place his articulating apparatus so as to produce the required sound. Sometimes it will be found that he can readily do this when shown how. It is then only necessary to insist that he take the requisite amount of trouble every time he speaks. Other patients, especially adults, have the greatest difficulty in accustoming themselves to the change. The great point is to begin early. The acquiring of a new sound in his own or a foreign language is to an adult often an impossibility.

2. Organic defects of the organs of speech may be congenital or acquired, and lead to the same vices of articulation mentioned above, but often in a much higher degree; at the same time the voice may be changed in quality, acquire a nasal twang, etc. Here the production of the normal sounds is an impossibility, even if the patient is instructed how to do it.

Hare-lip interferes especially with the pronunciation of the labials; cleft palate, and congenital defect of the soft palate and uvula, with the gutturals, besides giving a nasal twang to all sounds.

The tongue may be bound down to the floor of the mouth by a short frænum, causing thickness of speech and imperfect utterance of the linguals.

All these conditions must be ascertained by inspection. The treatment is surgical, followed at an appropriate interval by instruction in speaking.

Excision of the tongue for cancer interferes less with articulation than might be expected; *d*, *t*, and *l* are the only sounds which are lost, and the patient is able in a little while after the operation to make himself understood.

The larynx has little to do with articulation. Disease there causes aphonia. Even after its total extirpation patients have acquired the power to speak, setting in vibration the column of air contained in the pharynx.

3. Nervous diseases may cause literal as well as other defects of speech. The diagnosis must be based on a careful review of all the symptoms. The mode of development of the stammer is of the greatest importance.

Most characteristic in this respect is the defect in bulbar paralysis. In this disease the ganglion cells in the medulla oblongata are destroyed one after the other. The process usually begins in the nucleus of the hypoglossal nerve, and extends to the facial, spinal accessory, and glosso-pharyngeal. Wherever it extends it is accompanied by a paralysis of the muscles supplied by the affected ganglion cells; and as the tongue, lips, and palate are successively involved, the sounds formed by

these parts become indistinct, and finally disappear. In this way the patient loses the power to form the linguals; paresis of the lips causes at first disappearance of *o* and *u*, later of the explosives *b*, *p*, and *d*; when the disease extends to the uvula the nasal cavity is not properly shut off, and, besides the nasal quality which is given to it, the voice becomes much weaker from the large quantity of air which escapes through the nose. At the same time the lips, tongue, and palate are paralyzed for ordinary movements to a corresponding degree; whistling is impossible, swallowing difficult, and there is marked atrophy of the muscles with reaction of degeneration (Erb). There is no true aphasia nor amnesia, but speech may finally be entirely lost by the successive elimination of its component sounds. These changes are eminently progressive in character, and usually slow. The process is then one of sclerosis. But the same symptoms may appear rapidly, from hæmorrhage or embolism. During the prodromic stage, with heaviness of speech and occasional difficulty of articulation, diagnosis is not easy.

In paretic dementia the symptoms are more complicated. The disease-process is scattered through the greater part of the nervous system. If the medulla is involved there may be much the same defects of articulation as in bulbar palsy, but they never reach so high a degree. At the same time there is apt to be marked tremor of the face and tongue, elision of syllables, loss and misapplication of words, and weakening of the logical powers. In a typical case it may be possible to make the diagnosis from the speech alone. It should be remembered, however, that stammering and stuttering may coexist with congenital mental defect and simulate this condition closely. The occurrence of delusions of grandeur and the somatic symptoms will then decide.

Multiple sclerosis may or may not cause disturbances of speech, according to the location of the areas of induration. When the cerebrum is affected it is apt to be so in the subcortical portion, and the fibres coming from the left third frontal convolution may be involved. If they are involved, they may be cut across, and aphasia will then result. Usually they persist, altered more or less by the sclerosed tissue around them, motor impulses are transmitted through them with difficulty, and speech becomes measured and slow. This is called scanning. At the same time there is irregularity in the force with which syllables are brought out. The voice is monotonous and on a high key. But areas of sclerosis may occur below the basal ganglia, and cause true stammering.

In ordinary right-sided hemiplegia speech may suffer from implication of the fibres of the knee of the internal capsule, and possibly from affection of the basal ganglia, though the latter is not proved. Clinically, when aphasia of this origin passes off there is generally left an indistinctness of articulation which coexists with partial paralysis of the tongue and lips. This is not observed with aphasia of purely cortical origin.

The treatment of these forms of stammering is simply the treatment of the disease which causes them.

Functional diseases are not often the cause of a literal dysarthria. In chorea, if the lips and tongue are affected, speech is irregular or absent during the spasm. This, however, is not the result of any disorder of the central speech-mechanism. *Henry S. Upson.*

[1] Kussmaul: Störungen der Sprache.

STARCH (*Amylum*, U. S. Ph.; Br. Ph.; *Amyli Tritici*, Ph. G.; *Amidon*, Codex Med.—also, *Fécule de Pomme de Terre*, Codex). A vegetable assimilation-product, having the composition $C_6H_{10}O_5$, occurring in nearly all phænogamous plants, and in some others in the form of solid, rounded, or peculiar-shaped, usually laminated, microscopic granules. The official starch of the above pharmacopœias is that of wheat only, *Triticum vulgare* Linn.; but, as there are several others of excellent quality, prepared on a large scale for domestic and manufacturing purposes, the above restriction, at least in this country, is not always heeded.

Starch is primarily formed, either directly, or, as is more probable, through the medium of some soluble hydrocarbon, like sugar, in the chlorophyll corpuscles of the leaves and green parts of plants, by the aid of sunlight, from the carbon dioxide of the air, and water. It is one of the steps in plant-assimilation. The granules first appear in these corpuscles as exceedingly minute, trans-

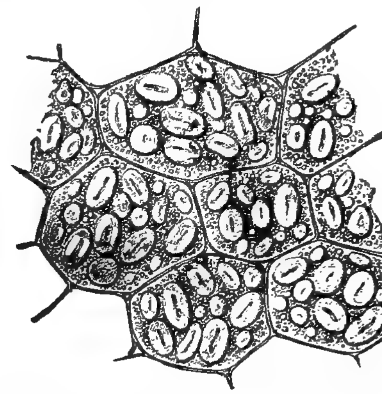

FIG. 3693.—Section of Seed of Vetch, *Vicia Sativa Linn.*, showing rounded granules of starch in cells otherwise filled with granular nitrogenous substance. $\times \frac{140}{1}$.

parent particles; as they grow they may remain within the starch-forming corpuscle, or they may rupture and protrude from it. The starch does not remain long, nor does it become fully developed in size and markings in these growing parts of plants, but, becoming changed to a soluble form (sugar, dextrine, etc.), passes down through the

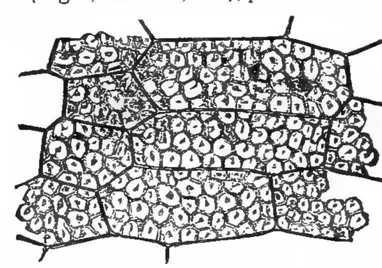

FIG. 3694.—Section of Seed of Maize, showing almost solid masses of polyhedral starch-granules completely filling the parenchyma.

cells and is consumed by the growth of stems, roots, etc.; that which is not wanted for immediate use being again transformed to solid granules in some quieter and more suitable organs, like pith (sago), rhizome (arrow-root), or in specially developed parts designed for storage in large quantities, like tubers (potatoes), fruits, and seeds (the

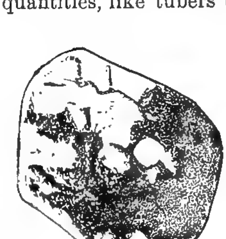

FIG. 3695.

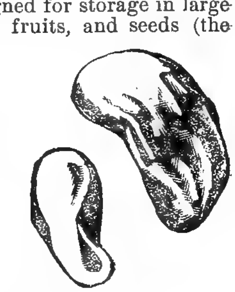

FIG. 3696.

FIGS. 3695 and 3696.—Granules of Potato Starch swollen by Boiling; those shown in Fig. 3696 afterward shrivelled as they cooled, or they may have lost some of their contents.

cereal grains, buckwheat, etc.). In these more permanent reservoirs the accumulation may be so dense as to crowd out all other cell-contents, or even to make the granules angular and polyhedral by pressure against each other. Figs. 3693 and 3694, copied, like all the others in this article, from Berg's "Atlas zur pharma-

ceutischen Waarenkunde," show the extent to which this crowding is carried.

General Description and Chemistry.—With the exception of some doubtful substances of scientific interest only, starch always occurs in granules of microscopic size, the largest (*Canna, Tous les Mois*) barely

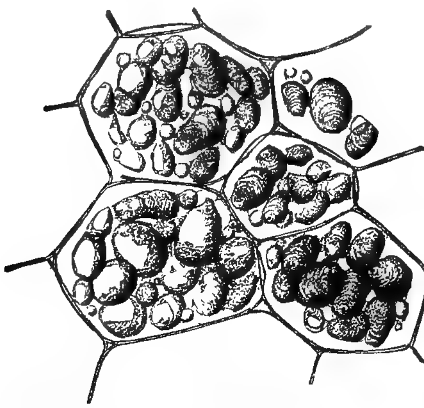

Fig. 3697.—Bit of Cellular Tissue from the Potato, showing very numerous loose starch-grains and very thin-walled parenchyna. × 190.

visible to the naked eye, the smallest (rice) the ten-thousandth of an inch in diameter. The granules are hard, highly refracting, of rounded, oblong, or peculiar outline, uniform or characteristic in each plant. If large, they almost always show a series of concentric lines or shades around a spot called the hilum, which may be

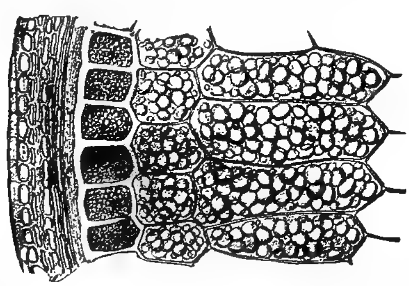

Fig. 3698.—Transverse Section of Wheat, with closely packed starch-granules, cuticular layers, wall of ovary, etc. × 190.

central, or more or less excentric. When dry, the hilum in many varieties season-splits and presents a variable stellate, branching, or single fissure, which, holding air when the starch is immersed under the microscope, looks black. Under polarized light in the microscope a dark cross, formed by two intersecting lines meeting at the

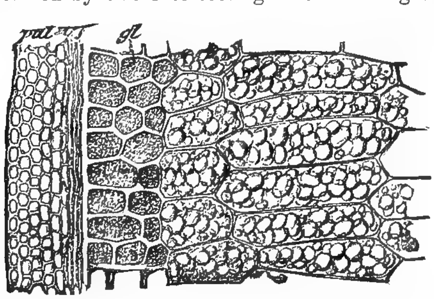

Fig. 3699.—Portion of Transverse Section of Barley; *pal*, husk (? spelye); *gl*, gluten-cells; *l*, pericarp; *T*, seed-coat. × 190.

hilum, gives starch a very characteristic appearance. Cold water has little effect upon starch, further than to make its rugæ a little less prominent, unless the granules have been triturated with sand to cut them to pieces, when a little is dissolved by it; but when heated in water to, say, 140° or 150°, the granules swell, lose their characteristic outline, and become less refracting to light; if the heat is carried still further the action upon polarized light is lost, and before the boiling point is reached they burst and form an opalescent granular mass (starch paste) in which some shreds of sac and tissue can usually be seen.

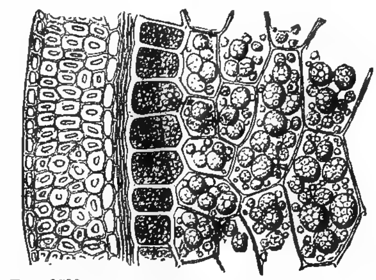

Fig. 3700.—Transverse Section of Oats, showing composite granules. × 190.

Starch of all plants has essentially the same chemical composition and reaction ($C_6H_{10}O_5$ or $C_{36}H_{62}O_{31}$, according to Nägeli). It is white, odorless, or nearly so, tasteless, becoming finally sweetish in the mouth from partial change; insoluble in alcohol and ether; boiled with about ten parts of water it gives a moderately stiff, bluish, translucent jelly or mucilage. Treated with a minute quantity of iodine, it is turned to an intensely blue color, which can be discharged by heat, returning again upon cooling.

Starch is not a homogeneous substance, but consists of at least two constituent parts, one more soluble than the other, called granulose; the other, which comprises the skeleton of the granule, is more like cellulose itself. Treated with diluted acids, heat, diastase, or one of a number of other vegetable or animal ferments, starch is converted into dextrine, a substance in extensive use as a mucilage or size; and finally into grape-sugar or glucose, which is now made from it in great quantities, as a substitute for sugar in cheap confectionery, etc.

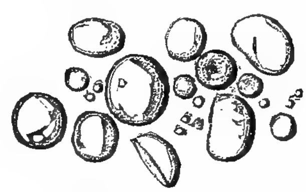

Fig. 3701.—Wheat Starch.

Preparation.—Figs. 3693 and 3694, as well as Figs. 3697 to 3700, will show how closely the starch is entangled with cellular structure, and other products of vegetable growth. The problem is to separate it and get it as completely clean as the succeeding figures (Figs. 3701 et seq.) show it.

This is generally accomplished by grinding and washing; for arrow-root, for instance, the pulpy rhizomes are cleaned with care and ground, then the pulp is washed over sieves; when the starch flows through with the water, it is allowed to settle, and then washed again and again until the soluble matters and the tissue are completely washed away. Sago pith is treated in essentially the same way. Potatoes are ground to a pulp and allowed to stand until the mucilaginous matters are disintegrated by decomposition, then washed as above. From wheat the starch is washed out of the glutinous dough, made by mixing a coarsely ground meal with a little water; this may be kneaded under a stream over a sieve, or it may be put in large bags and rinsed and pressed until the starch is all washed out from the gluten. The processes, of which this is the merest outline, have considerable variety in detail and in the machinery and conveniences used.

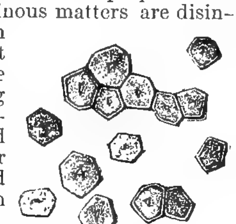

Fig. 3702.—Maize Starch.

Varieties.—The only certain means of determining from what source a given specimen of starch has been derived is to examine it microscopically, when the size, shape, markings, and other visible peculiarities of the granules will generally suffice to make it certain. The

following characteristics of the commoner kinds are magnified uniformly three hundred and fifty diameters.

1. *Wheat Starch* (*Amylum*, U. S. Ph., etc.). "In irregular, angular masses, which are easily reduced to powder; white, inodorous, and tasteless; insoluble in ether, alcohol, or cold water; under the microscope appearing as granules, mostly very minute, *more or less lenticular in form, and indistinctly, concentrically striated.* Triturated with cold water, it gives neither an acid nor an alkaline reaction with test-paper. When boiled with water it yields a white jelly, having a bluish tinge which, when cool, acquires a deep blue color on the addition of test solution of iodine" (U. S. Ph.). The only part of this description characteristic of wheat starch alone is that which is italicized. The granules average about 0.050 millimetre in diameter.

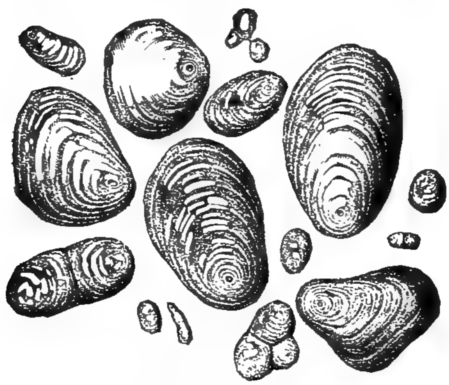

FIG. 3703.—Potato Starch.

FIG. 3704.—Arrow-root.

2. *Maize*, or *Corn Starch*, is smaller than the preceding, about 0.030 mm. in diameter, of polyhedral form, with central hilum.

3. *Rice Starch* resembles maize starch, but is very much smaller.

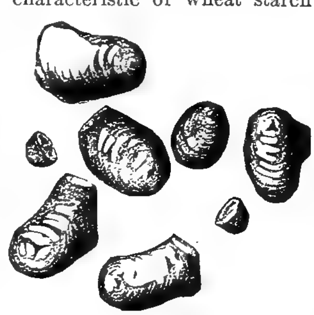

FIG. 3705.—Sago.

4. *Potato Starch* consists of two classes of granules mingled together—fine spherical ones, from 0.01 to 0.03 mm. in diameter, and large ovoid ones with very excentric hilums and very distinct *rugæ*, recalling oyster or clam shells, from 0.14 to 0.18 mm. long.

5. *Arrow-root* is finer than potato starch, which it somewhat resembles; the granules are more spherical, with blunter, thicker ends, very distinct excentric fissures, and less distinct *rugæ*. Canna starch, a variety of arrow-root, has enormous granules, nearly twice as large as those of potato. Neither of these varieties has the small forms of that from potato.

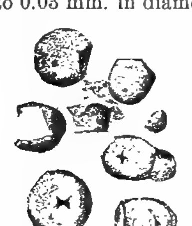

FIG. 3706.—Tapioca.

6. *Sago* has medium-sized (0.04 to 0.07 mm.), oblong, rather irregular, often faceted, sometimes shoe-shaped granules, with excentric hilum and pretty distinct *rugæ*. The sago of commerce is often half-cooked, with many of the granules destroyed.

7. *Tapioca:* spherical, medium-sized granules, with large facets; commercial tapioca is also partly cooked.

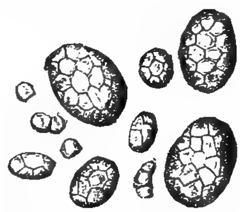

FIG. 3707.—Oat Starch.

Besides the above are the starches of numerous familiar grains and roots, which are not separated for sale or use, but which are of interest in detecting adulterations, mixtures, etc., or in identifying the powders of drugs. The three accompanying cuts will serve as illustrations of this large class.

Medical and Surgical Uses of Starch.—This substance can in no sense be called a medicine, as it is absolutely without physiological action. It is the type of crude carbonaceous or non-nitrogenous food, and its conversion into sugar in the mouth and intestine is one of the elementary facts of digestive physiology. As a toilet powder the finer varieties—rice and corn starches—are in universal use, and one or other of these is the foundation of most of the proprietary powders.

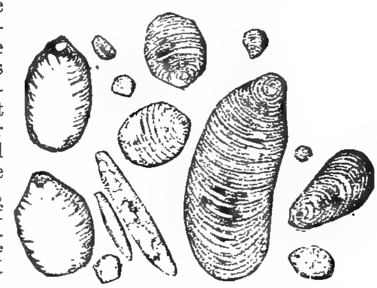

FIG. 3708.—Turmeric Starch.

Boiled starch, and especially the flours of starchy substances, are frequently used as poultices, but they are not so convenient and suitable as the mucilaginous flours of linseed and slippery elm.

Starch mucilage is occasionally used for immovable bandages, but it is less adhesive and less suitable for this purpose than flour-paste, glue, dextrin, silicate of potash, or plaster-of-Paris. One part dissolved glue, as prepared for cabinet-makers' use, and two or three of starch mucilage, a little thinner than the laundress uses it, mixed and applied hot, make a most excellent combination for such bandages—light, very stiff, and agreeable in color.

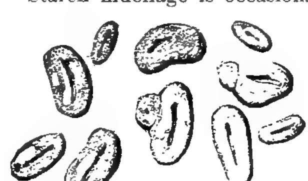

FIG. 3709.—Vetch, or Lentil Starch.

There are two officinal preparations of starch: the Glycerite (*Glyceritum Amyli*, U. S. Ph., ten parts of starch dissolved in ninety of hot glycerine), is a permanent translucent jelly, useful in moistening pill masses, for emulsions, and similar purposes. Iodized Starch (*Amylum Iodatum*, U. S. Ph.) is rather a preparation of iodine. It is made by triturating five parts of iodine with ninety-five of starch, with the aid of a little water. It is a blue-black powder, and a suitable preparation to administer for free iodine if it is desired to give that drug internally. Starch is related, pharmaceutically, to the mucilages, chemically to sugar. *W. P. Bolles.*

STATE MEDICINE. John Simon, C.B., F.R.S., for many years chief officer of the Local Government Board of England and Wales, says in a report made in 1874. "In my recent Annual Report the vast amount of injury which is suffered day by day in this country through diseases well known to be preventable, was referred to, in regard to the duty it imposes on all who have undertaken to serve in the new sanitary organization of the country, and I submitted that the Local Government Board, viewed as a Central Board of Health, and the more than fifteen hundred district authorities which,

each with its medical officer of health, locally administer the health laws, may be regarded as having had their respective functions assigned to them in special and systematic relation to that state of things." [1]

Professor Loewenthal, of Lausanne, gives as his third division of instruction in hygiene: "L'enseignement particulier pratique, destiné aux médecins qui aspirent aux postes d'application de l'hygiène, . . . tels que ceux des médecins attachés aux services sanitaires publics (municipaux ou de l'État);" and a recent American writer on the functions of Government says, that "it is the business of Government to do for the mass of individuals those things which cannot be done, or cannot be so well done, by individual action."

In these three quotations we have well set forth, from the theoretical, educational, and practical stand-points, the comprehensive character of the work which, in those countries where the functions of Government have been most progressively developed, is included under Public Hygiene, or, what is better designated, State Medicine. In articles found elsewhere in the HANDBOOK, as Sanitary Inspection, Sewerage, Quarantine, Food Adulterations, have been discussed some of the principal subjects included properly within the scope of State Medicine; quarantine, as generally understood, being a function of General Governments; sewerage and sanitary inspection that of Municipal or Local Governments; while the detection of food adulterations is usually in part performed by General Governments and in part by municipal authority.

It is evident that, whatever theory might indicate as to the duties peculiar to a General Government, on the one hand, and to municipal authorities on the other, the form of government—whether it be an autocracy, such as Russia, or a democracy, as Switzerland or the United States—will be a primary factor in determining the extent to which the term *State Medicine* will have any distinctive meaning or importance. Our personal conception of what should properly be included under the term has grown out of a practical experience of some years, and is derived wholly from the stand-point of results obtained, and quite apart from any preconceived theories. *Whatever system is found to save to the State the largest number of useful lives (in esse or in posse, e.g., workers or the children of our communities), and which further nurtures and maintains them in the best possible condition of physical, intellectual, and moral health is the best system.*

From this definition it will at once appear that in our opinion the function of Government is to make such enactments as will give ample powers to central authorities to maintain efficient quarantine systems, both internal and external; to endow such institutions as will supply the necessary education in practical hygiene to medical health officers, sanitary engineers, etc., and to establish laboratories wherein those scientific investigations which appertain to the discovery of the causes of disease, and to the measures to be taken for their limitation and prevention may be carried on. At the instance of the central authority must further be enacted such legislation as shall clothe municipal or district authorities with ample powers for the isolation of those suffering from contagious diseases, and for the institution of such works—sewerage systems, public water-supplies, regulations for the construction of buildings, etc.—as shall conduce to the maintenance of the public health in the highest possible degree. Finally, it comes very naturally within the scope of State Medicine to encourage the teaching in all schools of those principles which regulate the life of the individual, as regards either personal conduct or the regulation of the home, in those matters which bear most directly upon the preservation of health, and in some instances upon its improvement.

Having, in general terms, outlined the scope and province of State Medicine, we may state, what at once is apparent, that climate, aggregations of people, occupations, etc., will determine to what extent the functions of the State shall be exercised in order to conserve the highest interests of the people. From what has been witnessed in the past, it is plain that legislation, at first sight often seemingly opposed to some individual interest, may be expected to fall, in many respects, short of what the needs of the general community demand; but clear conceptions of what is required, and persistent efforts to make the public realize wherein their highest interests consist, are necessary before legislation is likely to supply the facilities for real progress in State Medicine.

It would be of interest were we to give a history of the advances of State Medicine, and the degree in which the principles already laid down have been carried into practical effect in different countries; but the still crude condition of State Medicine in many countries would detract very much from any practical value appertaining to such a statement, even did space permit. Our purpose will, we judge, be equally well served if we indicate the scope of State Medicine in those countries where it has reached its highest state of development. It is everywhere readily conceded that in State Medicine, in so far as regards its practical application to the ordinary conditions of society, England has, up to the present, been in advance of all other countries; and further, that the scope of the work of the Local Government (Central) Board is wider, and the relations existing between the Central Board and Municipal Sanitary Authorities are closer and better defined, than in any other English-speaking community. Since the cholera years 1848–53, there have been framed various Public Health Acts, in which have been developed to a considerable degree the principles already enunciated. These Acts are consolidated in the English Public Health Act of 1875. The whole of England and Wales is divided into urban and rural sanitary districts, governed respectively by urban and rural sanitary authorities. An Urban district is either a borough under the supervision of the mayor, aldermen, and burgesses, acting under direction of the Council, or an Improvement district under Improvement Commissioners, or a Local Government district under its Local Board of Health.

A Rural Sanitary District is an area not included in any of the foregoing, and the guardians of the union (Poor Law Guardians) form the rural authority of such a district. Over the Local Sanitary Authorities there is the Local Government Board, which has supreme control in many respects in matters relating to the public health. London City does not fall within the operations of the General Act. Local Sanitary Authorities are elected by the people for terms of three years, and have all necessary powers to levy rates for necessary sanitary improvements, and in those cases where continued neglect to protect the public is evident, the Central Board can require public works to be undertaken by the municipality. Similar central powers to some extent exist in France; but in few countries does this general control by the central authorities extend to matters other than enforcement of measures for the control of outbreaks of contagious diseases.

As regards the present position of State Medicine in the United States, it may be said that to the American Public Health Association, a non-official body, though including most prominent Federal and State sanitary officials, is due in large measure such progress as has been made during the past fifteen years; and that, as a result of its persevering efforts during an epidemic of yellow fever of unwonted extent and severity, was established, in 1878, the National Board of Health, a body appointed, and supplied with grants, by the Federal Government. Since 1882, the money grants which had enabled the Board to institute investigations of great interest and importance regarding the causation of disease, etc., have, through political prejudice, been in great part withheld, and but little practical work has been done by it; but there is reason to suppose that this anomalous state of affairs will soon be remedied. In the meantime, to the Marine Hospital Service has been committed the protection of the country against foreign outbreaks of disease, in so far as the Federal Government is concerned.

A limited amount of experimental work in the field of bacteriology is still carried on under the auspices of the National Board of Health; but work such as that done by the Governments of England, France, and Germany

is conspicuously limited in amount. The field of contagious animal diseases is in a much more advanced state, controlled as it is by the Bureau of Animal Industries, under the Department of Agriculture.

In keeping with State autonomy the State legislatures have done, in some instances, a considerable amount of sanitary work. With a few exceptions all the States of the Union have State Boards of Health, varying greatly in their powers and status.

In some instances these organizations are crude, with limited funds and equally limited powers. Indeed, the control which State Boards have over Municipal Health Boards is of the most limited character, being little more than advisory. The Local Boards, which by some State enactments (*e.g.*, those of New York State) are compulsory, have in a few instances statutory laws comprehensive and uniform in character under which action may be taken. Their work is done almost wholly under municipal by-laws, which are naturally of the most varied character, as regards both the extent and the thoroughness of their execution. In some instances (as in New Jersey) State Boards have control of animal diseases; while in others (as in Illinois) they are Boards for the Regulation of the Practice of Medicine; and in others, again (as in New York), for the registration of births, marriages, and deaths. In Massachusetts practical laboratory investigations have, to some extent, been carried on from time to time by the State Board. The first State to make such investigations systematically is the State of Michigan, where a hygienic laboratory is being erected at Ann Arbor, at a cost of $30,000, with an additional $5,000 for its equipment. The staff will consist of a professor of hygiene, and an assistant professor. There will be a course of lectures by the Professor of Mechanical Engineering on "Heating and Ventilation," by the Professor of Civil Engineering on "Sewerage Systems," and by the Professor of Law on "Public Health Laws." Special laboratories for the various branches of the work will be established. The main object of the laboratory, as stated in the memorial asking for its establishment, is to conduct original investigations into the causation of disease. This new department, added to the very efficient work of the State Board in other matters, will place Michigan in the van of progress as regards State Medicine.

In Canada, State Medicine is in a position which compares favorably with that in the United States. With two exceptions all the provinces have some form of State organization, while the Federal Government, by the Act of Confederation, has charge of quarantine, vital statistics, and food adulterations. In many respects the provincial statutes are modelled after English Public Health Acts. For instance, in the Province of Ontario, the most advanced in State Medicine, there is a Central or Provincial Board, whose duties and powers are defined by statute, and to it are given powers for investigating matters bearing upon the public health, and very complete facilities for acting promptly and effectively in threatened or actual outbreaks of contagious disease, whether occurring as a danger from without or from within. The Provincial Board has ample power, in accordance with statutory by-laws, to compel action to be taken by Local Boards, whose organization is compulsory, when contagious disease occurs in their municipality. It also requires the submission to it of all schemes for the establishment of public systems of sewerage and water-supply. So far very little experimental sanitary work has been done in Ontario, there being no special facilities enabling the Board to undertake such work. A special staff of medical health officers and sanitary police, under the direct control of the Provincial Board, has, in time of need, been organized to limit and suppress epidemics of disease likely to get beyond the control of individual municipalities. In other Provinces larger districts are assigned to medical officers, who act during epidemics, while elsewhere, as in many States, municipal councils have powers as health officers assigned to them.

That part of State Medicine which deals with practical instruction in this science has, in Europe, been prosecuted in varying degrees in different countries. To such work as that carried on by Parkes, Klein, Creighton, Sanderson, Baxter, Smith, and others in England; to the investigations of Pasteur, Chauveau, Duclaux, Chamberland, and others in France, and to the bacteriological investigations of Koch, and the chemical studies of Pettenkofer in Germany, are we to attribute the present position of practical knowledge of hygiene. In some countries the instruction in public hygiene is of a limited character, being confined to a course of hygiene in some medical school. In others there are institutes of hygiene on the most extended scale, as, for instance, at Munich, Leipzig, and Copenhagen. In Hungary the province of instruction in State Medicine is of an extended character. M. Trefort, the Hungarian Minister of Education, expresses the view that hygiene should be taught in all secondary or high schools, and that it can only be properly done by medically trained hygienists. He has, therefore, created in the medical faculties a special course of instruction for physicians aspiring to the position of professors of hygiene for secondary schools. At Pavia and Turin, in Italy, and at Charcow and Moscow, in Russia, are important hygienic laboratories; and Stockholm has an excellent institute of hygiene, established at a cost of 20,000 francs.

The reader will perceive, from the illustrations here given, that these State organizations were originally started with the object of limiting outbreaks of contagious disease. They employed first, of course, the crude methods then in use, but have gradually improved upon them as a result of much scientific and experimental work. State Medicine was a creation of necessity in times of public danger, but its future development will be in proportion to the scientific character of its work, and to the appreciation on the part of the public of the economic and beneficent results of such work.

Peter H. Bryce.

STAVESACRE (*Staphisagria*, U. S. Ph.; Staphisaigre, Codex Med.). The seed of *Delphinium Staphisagria* Linn.; Order *Ranunculaceæ*. This is a showy annual or biennial herb, arising from a stout, tapering root, by an upright, branching, hairy stem, about a metre high. Leaves alternate, on hairy petioles, and themselves pubescent or hairy beneath; the lower long-stemmed, of from seven to nine spreading, lanceolate lobes; the upper more and more simple; those of the inflorescence small, sessile, and simply lanceolate. Flowers irregular, large, in open racemes or panicles, about two centimetres across; calyx of five petaloid sepals, the three upper erect, the middle one spurred at the base, the two lateral ones broad, rounded, and spreading. Petals four, the two upper narrow, erect, sending spurs into that of the upper sepal; the two lower rounder. Stamens numerous; carpels three, ten-, or twelve-ovuled. Sepals and petals pink or purple, the former tipped with green. Seeds pyramidal, four-sided, slightly curved, about half a centimetre long; brownish-gray externally, white and oily within, odorless, but bitter and acrid.

This plant is a native of the South European countries, Asia Minor, etc., and is also cultivated. The seeds are imported from the south of France and Italy. They were known to the ancients, and for twenty centuries have been used for about the same purpose as at present —killing pediculi and similar vermin.

Composition.—The seeds contain about twenty-five per cent. of a non-drying *fixed oil*, and about one per cent. of alkaloids, of which the following have been isolated and named: *Delphinine*, in fine, large crystals; *Staphisagrine*, amorphous; *Delphinoidine*, also amorphous; and *Delphisine*, in crystalline tufts. Of these, the first is the most important and active, the second least so, while the third and fourth resemble the first, but are weaker.

Action and Use.—Stavesacre is an active and poisonous drug, irritant to the skin and mucous membranes, causing itching, stinging, burning, sneezing, etc., as well as diarrhœa and vomiting. Of the alkaloids, Delphinine best represents it; rubbed into the skin it causes local inflammation, on the tongue burning and numbness, in

the stomach nausea and distress, and, when absorbed, cardiac and respiratory slowing, diminished spinal irritability, and sometimes mental disturbance. The others resemble delphinine, but are less intense. Delphinine reminds one of both aconitine (to which it is botanically related) and veratrine. Staphisagrine is somewhat peculiar; it is not very active, but appears to resemble curare in its action upon striped muscle.

Neither the crude drug nor its alkaloids are given internally, so its exact action has but little practical bearing. It has from a remote time been employed, either by itself or in ointments or other vehicles, solely for the purpose of killing pediculi, and related animal parasites, on man and animals. At the present time it is mostly consumed in veterinary practice, kerosene or petroleum, petrolatum, sulphur, and *unguentum hydrargyri* taking its place in human medicine. An ointment can be made with twenty per cent. or so of the powdered seeds, or with from one-half to one per cent. of the alkaloid.

Allied Plants.—The beautiful genus contains the Larkspurs, many varieties, and is closely related to the equally beautiful Aconites. For the order, see Aconite.

Allied Substances.—Sabadilla is another time-honored parasiticide of very similar properties to the above, and is used in the same way. Kerosene and petrolatum are put to the same uses. *W. P. Bolles.*

STERILITY IN THE FEMALE. Synonyms: Barrenness, infertility; Lat., sterilitas matrimonii; Fr., stérilité; Ger., Unfruchtbarkeit.

Sterility in the female implies an inability to bring forth a living child. It involves two points for consideration: First, her inability to conceive at all; and second, her inability to complete successfully the period of gestation. Many women never conceive at all. Many other women conceive, but are unable to complete the period of gestation.

Women who never conceive are said to be *absolutely* sterile. Women who have borne one or two children and do not conceive thereafter are said to be *relatively* sterile.

Etiology.—Several organs are involved in the process of genesis in the female. The essential element of this process is the ovum, which is supplied by the ovary. The ovum is conveyed from the ovary through the Fallopian tube to the uterus, where it meets the spermatozoa, and genesis follows. The semen reaches the uterus through the vagina. Consequently, the question of sterility involves the investigation of the condition of, 1st, the ovaries; 2d, the oviducts; 3d, the uterus; and, 4th, the vagina. In addition, upon the *general condition* of the patient alone non-conception often depends. Under this head may be classed the extreme gouty vice, the syphilitic taint, anæmia, great obesity, chronic alcoholism, and spasmodic dysmenorrhœa.

The Ovaries.—1. The investigation of the ovaries in sterility includes inquiry into the possibility of the absence or of the imperfect development of these organs, conditions rarely met with excepting when the other sexual organs are anomalous.

2. Inflammation, chronic or acute, of the ovaries may result in such adhesions of the organs that the ovum is totally prevented from entering the oviducts. It may lead to arrest of function, so that the ovum can no longer be matured. The ovary may become so embedded in inflammatory deposit that extrusion of the ovum from its capsule is no longer possible.

3. Structural degenerations of the ovary may exist, *e.g.*, cystic, carcinomatous, and sarcomatous, and are generally attended with sterility.

4. Displacement of the ovary, often attended with chronic inflammation, may place it beyond the reach of the fimbriated extremity of the Fallopian tube so completely that the ovum cannot be transmitted to the uterus.

The Fallopian Tubes.—1. Absence or defective development of the oviducts is usually associated with other abnormalities of the sexual system, and causes hopeless sterility.

2. Inflammation of the oviducts is a cause of sterility. It may affect the serous coat, resulting in such fixation of the tubes as to prevent the *morsus diaboli* from coming in contact with the ovary, or in constricting bands that occlude the calibre of the tube. It may attack the mucous lining of the canal, and result in the production of secretions which are destructive to the spermatozoa or the ova, or it may result in permanent occlusion of the opening of the tube, whence may follow collections of blood, pus, or serum. In either case the ovum is prevented from descending to the uterus, and sterility follows.

3. Degeneration of the tubal structures produces a hopeless occlusion of the canal, and thus causes sterility.

The Uterus.—Defective development of the uterus assumes various forms, such as its total absence, its undersize, or its abnormal lateral growth into either a unicornus or a bicornus uterus. Conoidal cervix, with the commonly attendant stenosis of the os, may be classed as one of the variations of defective development. The last-mentioned condition constitutes one of the most frequently removable causes of sterility.

Degenerations: 1. Myomata often cause infecundity, but they are not always a barrier to conception. The coexistence of this degeneration and of pregnancy constitutes one of the most serious conditions encountered by the obstetrician.

2. Sarcomata seem always to prevent pregnancy.

3. Carcinomata, if extensive enough, cause sterility. In their early stage conception is often possible, and is now and then encountered.

Abnormalities of involution: An excessive involution (hyperinvolution) or a deficient involution (subinvolution) often constitutes a barrier to conception. The writer recently saw a healthy patient, aged twenty-seven, who bore a child at twenty-one years of age, and had not menstruated since that event. The uterus measured but one and one-fourth inch in depth. The organ may be still further decreased in size, even to a quarter of an inch.

Subinvolution of the uterus is often accompanied with an inflammatory state, completely preventing the occurrence of pregnancy.

Inflammation of the uterus or the circumjacent tissues is a very common cause of sterility. The morbid process, according to its seat, may be endocervicitis, endometritis, metritis including cervicitis, parametritis, or perimetritis. Often two or more of these conditions coexist, and render the cure very tedious. Endometritis may be accompanied by abnormal secretions destructive to the spermatozoa, there may be a dilated uterine cavity, the lining membrane of the uterus may be made so unhealthy that it becomes impossible for a fertilized ovum to secure a lodgement thereon, or the inflammation may cause more or less occlusion of the uterine orifices.

Displacements: Malpositions of the uterus include prolapse, flexions (retroflexion, anteflexion, and lateroflexion), and versions (anteversion and retroversion).

Anteversion and anteflexion exist most frequently in nulliparæ. Retroversion and retroflexion exist most frequently in those who have borne children. Lateroversion and lateroflexion are present when an inflammation has existed in either broad ligament, resulting in shortening of the ligament, or when some foreign growth or an inflammatory deposit exists on the side of the pelvis opposite to the displacement, crowding the uterus away from its normal condition.

The Vagina.—This organ may be so injured or may become the seat of discharges so fatal to the semen that it becomes a source of sterility.

Malformations: The vagina may be absent congenitally. Its occlusion is very rare. A severe vaginitis has been the cause of an almost total occlusion by the agglutination of the vaginal walls. The hymen is sometimes so hypertrophied that it becomes a barrier to copulation. Unnatural shortness of the vagina renders it incapable of retaining the semen a suitable length of time.

Inflammation: Vaginitis nearly always produces discharges fatal to the semen. It is occasionally productive of that condition of spasm called vaginismus, but this may also be caused by other conditions.

Injuries: Extensive perineal lacerations often become causes of sterility. Fistulæ may also prevent conception.

Degenerations: Elephantiasis labiorum prevents coitus, and thus becomes a barrier to insemination. Extensive urethral caruncle often interferes with successful intercourse.

General State of the Patient's Health.—An indefinable something in the patient's general condition is oftentimes the apparent cause of a sterility. The proof of this statement consists in the fact that women, sterile when in poor health, often conceive when their general condition has been improved by remedies, by change of climate, or by travel. Some women are sterile because of the presence of discharges from the genital tract which have their origin in a systemic taint. The lithæmic state, for example, may give rise to such discharges, which cease when an anti-lithic course of treatment has been followed, and conception thereafter may follow. Many cases of sterility of this form have been wholly removed by a course of treatment at suitable mineral springs.

Under this head may be also mentioned that variety of sterility which is dependent upon some obscure incompatibility of the parties, illustrations of which every physician of experience has encountered. A woman, sterile in many years of married life, who has been, for this reason, abandoned by her husband, eventually secures a divorce, is married to a second husband, and bears a number of children. The old illustrations of Augustus and Livia, and of Napoleon and Josephine, are quoted by writers on sterility.

Diagnosis.—It is not always that only one of the foregoing obstacles to conception is present. Very often two or more of them coexist. When the causes of sterility are manifold in the same patient, it is obvious that the skill of the gynæcologist will often be taxed in recognizing and removing them. A complete diagnosis can be arrived at only by an exhaustive examination. It is always a safe plan for the physician to endeavor to find all the possible causes of sterility in each patient.

It must be confessed that only too often does it occur that, after every discoverable removable obstacle to conception has been corrected, sterility will still exist.

Prognosis.—In no condition is the prognosis more uncertain. In a general way, it may be stated that imperfect development or marked malformations constitute an absolute bar to conception.

In the same manner, it may be stated that removable obstacles to conception, as inflammations, flexions, versions, stenosis, some vaginal occlusion, or fistulæ, may be treated with a fair prospect of fruitful results. The apparently complete removal of these obstacles, however, only too often fails to render the woman fruitful.

Treatment.—A successful treatment of sterility in the female is secured by removal of all the obstacles to conception. Such treatment does not include that of sterility in the male, although many gynæcologists investigate the male first, since about one case in ten of infecundity in marriages has its origin in the male. With this branch of the subject, however, the present article has nothing to do.

After the physician has discovered as many obstacles to conception as he can find, he must set about removing them. Insufficient treatment nearly always results in failure. In no department of gynæcology is more persistence in treatment demanded.

Urethral caruncles, vulvar vegetations, and other sensitive excrescences must be removed or destroyed.

Vaginal stenosis or contraction must be stretched and the canal must be kept patulous.

Cervical stenosis must be overcome by sea-tangle or tupelo tents, or by stretching with dilators. Division of the cervix by the hysterotome has been much practised successfully in the past, but is at present falling into disuse, forcible dilatation being preferred.

Uterine deviations must be corrected. Versions can often be rectified by suitable pessaries. It has been suggested that anteversion may be corrected by allowing the bladder to become distended with urine, thus pushing the fundus uteri backward and throwing the cervix sufficiently forward to place the os in a direct line with the seminal ejaculation, thus facilitating the entrance of semen into the cervical canal. Similarly, retroversion, it is alleged, may be temporarily corrected by allowing the rectum to become distended with fæces, whereby the fundus uteri may be crowded forward.

Flexions demand the use of the intrauterine stem-pessary.

Hyperinvolution may be treated with the galvanic intra-uterine stem-pessary. Similarly, attempts may be made to stimulate the growth of an imperfectly developed uterus.

Inflammations must be treated *secundum artem.* Various antiphlogistic methods of treatment are in vogue. Cauterizing applications, hot-water douches, glycerine tampons, the dry treatment of Englemann, etc., each has its adherents.

Morbid growths on the endometrium must be removed or destroyed.

Quite exceptionally, the method of introducing semen into the uterus by means of a syringe and a tube has been used. it is alleged, successfully.

In the treatment of all cases of sterility the physician must never ignore the general condition of the patient. Systemic vices must be eradicated as far as possible. Many cases of sterility can be cured by general treatment. Repeated abortions indicate the possibility of the syphilitic taint. The existence of this vice in a marked degree is an almost certain obstacle to the chances of gestation being completed, and it must, therefore, receive continuous and persistent treatment for a period of at least two years. *J. H. Etheridge.*

STERILITY IN THE MALE. This term, in its accepted sense, implies inability to impregnate the female, from other causes than that of impotence or loss of the power of copulation (see Impotence). "Sterility not only does not include impotence, but is met with in subjects who are vigorous in intercourse, and who may ejaculate a fluid which, in the absence of minute examination, presents all the properties of normal semen. Sterility includes, first, azoöspermism, or the condition in which either no semen whatever, or unproductive semen, is secreted; secondly, aspermatism, in which spermatic fluid is not ejaculated; and, thirdly, misemission, or the failure to deposit fertile semen in the upper portion of the vagina. In the first variety intercourse and ejaculation are natural, but the essential anatomical elements are absent or dead, either because they are not formed, or are imprisoned behind an obstacle seated in the epididymes or vasa deferentia, or because they are unable to live in the medium in which they are suspended. In the second variety the ability to copulate is unimpaired, but the power to ejaculate is prevented by an impediment situated between the seminal vesicles and the urinary meatus In the third variety coition and emission are perfect, but fruitful semen fails to reach its proper destination in consequence of congenital deficiencies of the urethra, or of fistulous openings in that canal, resulting from inflammation, or of abnormal positions of the meatus" (S. W. Gross, "On Impotence, Sterility, and Allied Disorders of the Male Sexual Organs." Philadelphia, H. C. Lea's Son & Co., 1883).

1. *Azoöspermism* may be due: *a.* To congenital bilateral absence of the testes, or congenital bilateral deficiency of the epididymes or vasa deferentia. Such absence of the testes likewise results in impotence and may here be dismissed. Such deficiency of the excretory apparatus of the testes need not result in impotence, but prevents all escape of spermatozoa.

b. To non-descent of the testes into the scrotum. Individuals thus affected are potent; they are usually sterile, but may, in exceptional cases, be fruitful (S. W. Gross).

c. To affections of the testes. Bilateral atrophy, from whatever cause, always diminishes, and sometimes prevents, the formation of spermatozoa. Simple parenchymatous orchitis results in absolute azoöspermism. Partial destruction, by malignant or other new-growths, does

not necessarily result thus. After syphilitic orchitis spermatozoa may return under proper treatment.

d. To bilateral obliteration of the epididymis and vas deferens, thus preventing the escape of spermatozoa from the testes. This is by far the most frequent cause of azoöspermism, and in the great majority of cases is due to gonorrhœal epididymitis. It may also be due to tubercular, malignant, or syphilitic disease of these organs. It is held by some good authorities that epididymitis of one side may abolish the function of the opposite gland.

e. To nervous exhaustion or neurasthenia, attended with abnormal seminal and prostatic discharges, and with various degrees of impotence, all of which is usually brought about by onanism, venereal excesses, or ungratified desire. As a result of impaired nutrition induced by perverted innervation, the secretory activity of the testes is interfered with, and either the evolution of the spermatozoa is arrested, or their number and activity are diminished (S. W. Gross).

The diagnosis of azoöspermism must be made by repeated examinations of the ejaculated fluid, if such there be, under the microscope.

The treatment is in many cases evidently *nil.* In advancing atrophy of the testicles, galvanism gives some promise of good. In syphilitic orchitis or epididymitis, prompt and persistent treatment may avert the calamity or restore fertility. In bilateral epididymitis from other causes, early and vigorous antiphlogistic treatment will often prevent occlusion. But even if this exist, it may sometimes be overcome by iodide of potassium, bichloride of mercury, and the local use of mercurial ointment or oleate of mercury.

2. *Aspermatism,* or the failure to ejaculate semen during copulation, may be due to the following causes :

a. Organic lesions preventing the discharge of seminal fluid into the urethra, or preventing its ejaculation through the meatus. Congenital occlusion, absence or deviations of the ejaculatory ducts, have occasionally been met with. Stricture of these ducts and deviation of their orifices, due to inflammation or injury, are more frequent. This may follow gonorrhœa, blows on the perineum, or the operation of lithotomy.

Semen having been delivered in the urethra may fail to be discharged properly, owing to some obstruction anterior to the prostate gland. If this obstacle is in the posterior portion of the canal, the fluid will pass backward into the bladder ; if near its orifice, the semen will flow out after erection has ceased. Stricture of the urethra is the most common of these obstacles. A stricture which permits the flow of urine when the penis is flaccid may prevent the escape of semen during erection. More over, according to Gross (*loc. cit.*) : "In these cases the fault is to be ascribed less to the organic contraction than to the spasm of the muscular walls of the urethra beneath the sensitive mucous membrane, through which the opening is temporarily occluded."

The escape of semen is occasionally prevented by a tight phimosis. Finally, it may be due to induration of the corpora cavernosa, which sometimes results from injuries, and sometimes seems to be associated with the gouty diathesis.

b. Aspermatism may exist in cases where there are no such organic defects or obstacles as are mentioned above, and no external anæsthesia. This is attributed by Rosenthal and others to the "absence of excitability in the lumbar reflex ejaculatory centre."

Such subjects commonly give the general symptoms of neurasthenia and a history of masturbation, sexual excesses, repeated attacks of gonorrhœa, etc. S. W. Gross is of the opinion that in many of them there will be found inflammation and hyperæsthesia of the prostatic urethra, with accompanying lesions, which maintain, and are probably the cause of, the diminished excitability of the lumbar ejaculatory centres. This is important, as indicating possible cure by the use of steel bougies and other appropriate treatment.

c. Anæsthesia, or insensibility, of the glans penis is an occasional, though rare, cause of aspermatism, and a case is reported by Curling, in his work on "Diseases of the Testis," in which he relieved the difficulty by applying the acetum cantharidis to the gland.

d. Mental causes, such as disgust, anxiety, etc., may sometimes interfere with ejaculation, just as they often prevent erection.

Diagnosis.—The fact that semen is not ejaculated during intercourse is apparent to the patient himself, and will probably be the reason of his consulting the physician. The diagnosis as between the various forms, or causal conditions, depends on the history of the case, a careful examination of the genital organs, the question of whether semen escapes with the urine or from the urethra after intercourse, and on the consideration of other points which have been mentioned in the description of the different varieties.

Treatment.—A number of the organic lesions which cause aspermatism are plainly beyond the reach of treatment. In case of phimosis circumcision should be performed ; strictures should be dilated or divided. In the atonic variety, if the insensibility of the lumbar nerve-centres is associated with inflammation and hyperæsthesia of the prostatic urethra, this should be treated by the systematic introduction of the conical steel sound. If granular patches in the urethra fail to yield to this method, astringents, as solutions of nitrate of silver of from ten to thirty grains to the ounce, may be carried to the part by some of the catheter syringes or other applicators in vogue. If, on the contrary, the prostatic urethra is not sensitive and no stricture exist, tonics are indicated, as iron, quinine, strychnine, cold sitz-baths, and perhaps galvanism. In anæsthetic aspermatism the faradic brush to the penis or vesication of its surface, as in Curling's case, may succeed.

3. *Misemission.*—In this form of sterility fertile semen may be secreted and ejaculated, but for some reason it fails to be so deposited in the female organs as to come in contact with the ovum and impregnate it. This is usually due to malformations of the urethra, as hypospadias, epispadias, or fistulous openings in the urethra following injury or stricture. The subjects of these deformities are not always sterile, inasmuch as semen deposited at the mouth of the vagina may find its way into the uterus. Congenital or acquired shortening of the frænum may so displace the meatus as to direct it downward or backward, a fault which may be remedied by division of the frænum. *Edward W. Schauffler.*

STERNUTATORIES, or errhines, are substances which, when applied to the nasal mucous membrane, cause sneezing and increased secretion. Properly speaking, there is a distinction between the two terms, errhine being used to denote an agent which increases the nasal secretions, while a sternutatory causes sneezing only. But as the act of sneezing is almost always accompanied by increased secretion, the distinction between the two classes of remedies is practically without a difference.

In former times sternutatories were much more commonly employed than they are at present, and older writers were wont to lay great stress on the efficacy of these agents in the treatment of many apparently dissimilar conditions. Their use was recommended (1) to restore suspended respiration ; (2) to effect the expulsion of foreign bodies from the air-passages ; (3) to increase the secretion of the nasal mucus or of the tears, or to expel accumulated mucus from the sinuses ; (4) to awaken the action of the encephalon, restore sensibility, or excite uterine action. At the present time, remedies of this class are out of fashion, and the only applications to which they are put are to excite sneezing for the sake of the pleasurable sensations that it causes, to increase the nasal secretions in the dry stage of coryza, and to clear the nasal passages and the adjacent sinuses of accumulated mucus. It is possible, however, if the present tendency of attributing many and diverse morbid conditions to the score of nasal reflexes should prevail, that future generations will restore the sternutatories to their ancient rank among the most prized of therapeutic agents.

The list of substances which have been employed at one time or another for the purposes above enumerated is

as long as the moral law, and embraces nearly every drug which can be reduced to a fine powder, and even many gases, such as ammonia. To enumerate only a few of them, we have rosemary, lavender peppermint, spearmint, white and black hellebore, stavesacre, mustard, euphorbium, betonica, ginger, iris, the peppers, calomel, bismuth, the alkaline carbonates, ipecac, tobacco, sweet marjoram, and a host of others. At present this list is practically restricted to half a dozen substances, the chief of which are tobacco, ipecac, veratrum album, quinine, camphor, and cubebs. Tobacco snuff is seldom employed now, except as a luxury, but the others just mentioned enter, one or all, in varying proportions, into the composition of the different catarrh snuffs prescribed by physicians or sold as proprietary remedies.

The following are some formulæ for catarrh snuffs which may serve a useful purpose in the early, dry stage of a coryza, or later when there is an abundant secretion of tenacious mucus which is dislodged with difficulty: ℞. Quin. sulphatis, gr. xx. (1.3); potassii chloratis, ʒ j. (4.0); amyli, ℥ j. (30.0). M. ℞. Pulv. ipecac., gr. v. (0.3); quin. sulphatis, ʒ ss. (2.0); pulv. camphoris, ℥ ss. (15.0); sacchari albi, ℥ jss. (45.0). M. ℞. Acidi salicylici, gr. x. (0.6); pulv. camphoris, ʒ j. (4.0); pulv. acaciæ, ʒ ij. (8.0); pulv. cubebæ, ℥ ss. (15.0). M. ℞. Morphinæ sulphatis, gr. 2 (0.12); bismuthi subnitratis, ʒ vj. (23.0); pulv. acaciæ, ʒ ij. (8.0). M. This powder, as all others containing morphine, must be used with some caution, ʒ ij.–iij. (8.0–12.0) being as large a quantity as can be safely given to an adult in the twenty-four hours. An errhine which formerly enjoyed much repute was the cephalic snuff—pulvis asari compositus—composed of powdered lavender leaves, one part, sweet marjoram (origanum majorana), one part, and asarum, three parts.

In cases of suspended respiration tickling the interior of the nose with a feather will sometimes cause a deep inspiratory effort, followed by a sneeze, and thus restore the breathing. This is sometimes even more efficacious than cold affusions, slapping the body, and other means commonly employed; for the Schneiderian mucous membrane is among the last of the parts to lose its sensibility in cases of unconsciousness, and will often respond to this stimulus after the integument has become insensible.

Thomas L. Stedman.

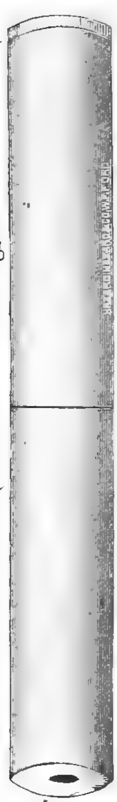

Fig. 3710.—Laënnec's Stethoscope. *a*, Plug; *b*, *c*, sections; *d*, aural extremity.

STETHOSCOPES. Historical Sketch.—The credit of having invented the stethoscope has been variously attributed to Hippocrates, Bayle, Hook, Laënnec, and others. It is certain, however, that Laënnec was the first to make the idea practically useful. He hit upon it accidentally, by using a roll of paper which he was holding in his hand. His first instrument was a cylinder of paper compactly rolled and kept in shape by paste. The stethoscope subsequently adopted was a cylinder of wood an inch and a half in diameter and a foot long, perforated longitudinally by a bore three lines wide, and hollowed out into a funnel shape at one end to the depth of an inch and a half. A plug of wood fitted into this hollowed extremity with a perforation through it of the same diameter as that of the rest of the tube. This was used in auscultating heart sounds. It was discarded in stethoscopes made at a later date. The instrument was made in two sections for convenience of carrying. Piorry introduced a more slender instrument, with ivory cap, and later this was altered and made of wood only. An instrument in which the pectoral end was trumpet-shaped, was devised by Dr. Williams, of London, about 1843. Since then a large number of monaural stethoscopes have been devised, and descriptions of them are to be found scattered through various medical publications. They have been made of metal, wood, hard rubber, papier-maché, and other materials, used either alone or in combination. Most of these stethoscopes are hollow, the bore of the tube being pretty uniform throughout, except at the pectoral extremity, where it is expanded and bell-shaped. Solid wooden stethoscopes have also been devised, but these are more especially useful in conveying percussion sounds when the method of auscultatory percussion is practised. The monaural instruments do not differ from one another in any important particular. A few are combination instruments, having

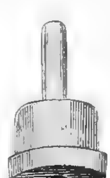

Fig. 3711.—Plug of Laënnec's Stethoscope.

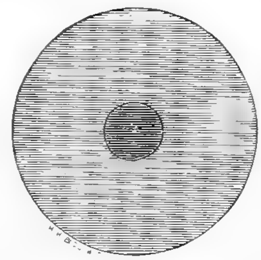

Fig. 3712.—Diameter of Laënnec's Stethoscope.

Fig. 3713.

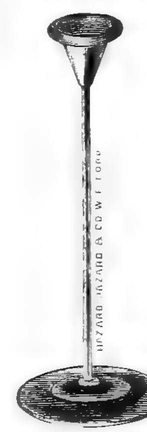

Fig. 3714.

Fig. 3715.

Figs. 3713, 3714, and 3715. Monaural Stethoscopes.

a percussor and pleximeter attached, or a clinical thermometer, a female catheter, etc., hidden away in them. Among others who have devised monaural stethoscopes may be mentioned Quain, Stokes, Arnold, Barclay, Elliottson, Dobell, Loomis, Burrow, Clark, Cammann, and Ferguson.

M. Landouzy, of Paris, in 1850, constructed a stethoscope with a bell-shaped chest-piece, with a number of flexible tubes attached, by which several observers at once could auscultate. A single tube was designed for each person, but by the use of two tubes it became a binaural instrument. It was necessary to hold the tubes in the ears by the hands, and it was not found to be of much practical use. Many years previously Dr. Williams, of London, had been accustomed to use a binaural stethoscope made of two metal tubes attached to the bell of an ordinary stethoscope, and with flat ear-pieces. This conveyed sound with increased intensity, but was inflexible, clumsy, and awkward of application. The double stethoscope of Dr. Leared, shown in the Great International Exhibition of 1851, was a great improvement. It is made entirely of gutta-percha. The two tubes are attached at one extremity to a bell-shaped chest-piece, and at the other to ear-pieces similar to those of the monaural stethoscope. These tubes being separated and applied to the ears, ex-

Fig. 3716.—Intracostal Solid Cedar Stethoscope.

erted a certain amount of pressure by their own elasticity. To use this instrument ordinarily in practice, however, would require three hands, one for each ear-piece, and another to manage the pectoral end. In 1851 Dr. Marsh, of Cincinnati, patented a double stethoscope. This had a membrane stretching over its objective end, and two gum-elastic tubes leading from the chest-piece to the ears. In this instrument the ear-pieces were inconvenient, and the sounds conveyed were muffled and confused. These circumstances rendered it of little value.

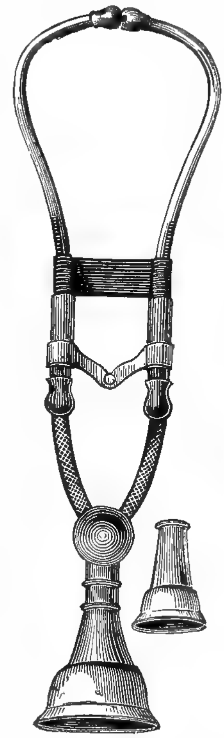

Fig. 3717.—Cammann's Binaural Stethoscope.

Dr. G. P. Cammann devised a binaural stethoscope which, after considerable labor and expense, was perfected in 1852. He was familiar with the instruments of Landouzy and Marsh, and his stethoscope, therefore, was not a new invention, but was, and is now, the best instrument of the kind devised. It is light, durable, easily carried, and a good conductor of sound. The attachment of a rim of soft rubber to the chest-piece, as devised by Dr. Snelling, is of advantage in some cases in applying it more closely to the inequalities of the chest. Oval chest-pieces are also made, which enable the end of the stethoscope to be pressed into the intercostal spaces. In most of the instruments now made the rubber band which served to draw the two tubes together is replaced by a spring. In the latest improvement the spring is placed in the screw which binds the tubes together (Fig. 3721). A considerable variety of flexible stethoscopes are now in use. The credit of having first used one is probably due to Dr. Pennock, of Philadelphia. They may be generally described as consisting of a chest-piece, long flexible rubber tubes, and round ear-pieces. The ear-pieces are held in place either by being firmly pressed into the meatus, or by a spring passing over the head or under the chin. A flexible stethoscope was devised by Mr. Brown, in which the ear-pieces are oval. When placed in the ear, with the long diameter vertical, they are said to remain readily in position. The differential stethoscope of Scott Alison is similar in mechanism to Cammann's, but has two chest-pieces, one for each ear, enabling the sounds from different regions of the chest to be conveyed to the two ears at the same time. The hydrophone is another instrument devised by Alison. It consists of an india-rubber bag, about the size of a large watch, and filled with water. Another inventor had previously constructed a wooden instrument filled with water, but it was not practically useful. Alison found that when water was interposed between two conducting media, sound was conveyed to the ear with increased intensity. The hydrophone may be employed as an instrument by itself, or in aid of the stethoscope.

Fig. 3718.—Scott Alison's Differential Stethoscope.

Dr. McBride has devised for use in auscultatory percussion a solid binaural stethoscope of hard rubber, with chest-piece sufficiently small to fit in the intercostal spaces. Dr. Constantin Paul devised a stethoscope with two flexible tubes leading to the ears, and a hollow chamber in the chest-piece connected with a rubber bulb by a long flexible tube. If the air in the hollow chamber is exhausted the instrument is held firmly against the chest. A modification of the chest-piece of Cammann's binaural stethoscope, which can be screwed on in place of the usual chest-piece, has been devised by the writer. In the pectoral end is an air-chamber, which is completely closed by pressure against the chest. Connected with this chamber by a small tubular opening is a rubber bulb, through which the sound-conducting tube passes. By pressure upon this bulb, when the instrument is held in position, the air is exhausted in the hollow chamber and the stethoscope is held firmly to the chest-wall.

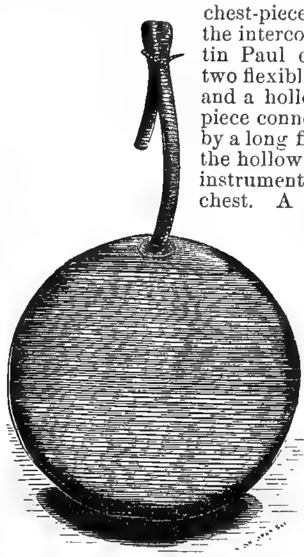

Fig. 3719.—Alison's Hydrophone.

Dr. Heineman, of New York, has devised an attachment to the binaural instrument, in which, by an admirably arranged piece of mechanism, the stethoscope is held firmly against the chest by means of a metal rod extending from the chest-piece to the chin, and both hands are left free.

Dr. D. M. Cammann devised a binaural hydrophone with the two tubes made of hard rubber, and thin hard-rubber caps at the aural extremities. The pectoral extremity is covered by a diaphragm of soft rubber, and the instrument is filled with water by means of a faucet. The chest-piece has been already described as a modification of the ordinary binaural stethoscope, and is held firmly against the chest, leaving both hands free. It is intended for use in practising auscultatory percussion.

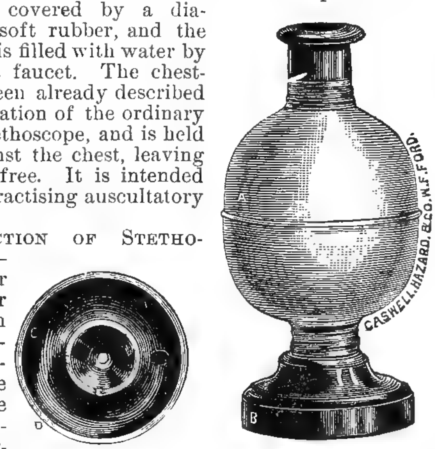

Fig. 3720.—Cammann's Modified Chest-piece. *A*, Rubber bulb; *B*, pectoral end; *C*, air-chamber closed by pressure against the chest; *D*, outer rim; *E*, inner rim.

Construction of Stethoscopes.—The rules for the proper construction of stethoscopes cannot, in the present state of our knowledge, be formulated with scientific exactness; nevertheless, a knowledge of the laws of acoustics and of the results of the experiments of others, will aid us in constructing instruments less faulty th n many of those now in use. In selecting a material, one should be chosen that, as far as possible, is light, durable, and a good conductor of sound. For the monaural stethoscope nothing has been found better than a light, firm, vibrating wood

like cedar. The fibres should run in the direction of the length of the stethoscope. Mahogany, deal, and lime-wood answer well, but the heavier woods, as oak, beech, lignum vitæ, and boxwood, are inferior and deaden the sonorous vibrations of the bodies upon which they are applied. The quality that makes wood desirable is the same that applies in its use in violins, in sounding-boards for churches, and in the walls of concert-rooms. Other materials, although inferior, are good conductors of sound. Ebonite, a preparation of india-rubber, has the advantage of being light and durable, and easily moulded into shape. The metals, horn, papier-maché, gutta-percha, and ivory are good conductors, and have all been used for this purpose. Hollow stethoscopes are most desirable, as some sounds are conducted best through the solid walls, while others are transmitted most perfectly through the enclosed column of air. The latter is the case with the aërial sounds of the chest, the solid wall of the stethoscope acting as a sounding-board, receiving and transmitting the weakest vibrations. In the practice of auscultatory percussion, a solid wooden stethoscope or the binaural hydrophone is most useful, as sounds produced in solids are best conducted through homogeneous media; but even in this case the ordinary hollow instrument will usually be found to convey sound with sufficient intensity for all practical purposes. The bore of the stethoscope and the hollow in the chest end should not be too large, else there will be caused a confused reverberation of sound; nor should the wall of the stethoscope be of great thickness, both on account of superfluous weight and because the weaker vibrations are thereby checked. It is best that the stethoscope should be of one material throughout and in a solid block. This is not essential, however, and in the binaural instrument is not possible. Theoretically the breaking of continuity, by having it in several pieces, would impair the conducting power; but practically the difference is found not to be as great as might be expected. Flexible stethoscopes, in which the tubes are of soft rubber, or of wire covered with some pliable material, are useful in some cases, but the sounds are modified by reverberation, especially when the tubes are long and with large hollows. The length recommended by Laënnec was one foot divided in two for convenience of carrying. This is unnecessarily long, and six inches is now the usual length. The length of the binaural instrument, from ear to chest-piece, varies from ten or twelve to sixteen or seventeen inches. Most of the binaural instruments have two chest-pieces, one small and narrow, the other trumpet-shaped, which can be screwed on at pleasure. The modified chest-piece may also be used, and can be screwed on in the same way. The smaller end can localize sounds best, and is easier of application to the chest; the larger is more useful in examining the chest rapidly. The edges should not be too sharp, but rounded off both toward the circumference and toward the centre. The ear-piece of the monaural stethoscope ought to be large enough to cover the concha and to close the external meatus. It may be flat, but the most convenient form is with a depression between the circumference and the centre, the latter being considerably elevated. The binaural instruments have small circular knobs, which should not be too large nor too small. If too large, they do not fit closely and allow external sounds to enter; if too small, they cause discomfort by pressure. No instrument will suit all ears, and a stethoscope should be fitted to the ear as a shoe is to the foot.

Fig. 3721.—Cammann's Binaural Hydrophone.

Value of the Stethoscope.—In considering the value of the stethoscope it is taken for granted that the instrument used is reliable, and that the auscultator knows how to use it. Some skilful auscultators advocate its continual use; others, equally skilful, advise that it be used only occasionally. The cause of this difference of opinion probably lies partly in difference in the acuteness of hearing and the extent of the training of different observers, and partly is a matter of habit. That the habitual use of the stethoscope does after a time render the sense of hearing less acute to the sounds heard over the chest, in immediate auscultation, is, I think, an undoubted fact. Yet the stethoscope is a valuable instrument, and although it is not always needed, often we cannot attain to a full knowledge of a case without making use both of mediate and immediate auscultation. Often a doubtful or half-heard sound has been clearly brought out and appreciated by the use of the stethoscope; but still oftener, I think, has a sound scarcely suspected with the stethoscope been made evident by the immediate application of the ear. It requires some practice to become accustomed to its use, especially to that of the binaural instrument. In the latter some sounds are exaggerated, while others are impaired, and there are not the distinctness and simplicity that there are when we use the ear or the monaural instrument. It is an acoustic fact that sounds are better heard with two ears than with one, and virtually the double stethoscope enables us to place two ears on the chest at the same time. The modified instrument increases the intensity of sounds both by bringing the pectoral end into the closest possible contact with the chest, and by both the hollow air-chamber and the rubber bulb acting as resonators. It also leaves both hands of the auscultator free. Alison's hydrophone may be used either by itself or placed between the end of the stethoscope and the chest, thereby increasing the contact and the conducting power when it is difficult to bring the inflexible end of the instrument into close apposition with the chest-wall.

The value of the stethoscope for purposes of modesty, cleanliness, and convenience, and for examining the supraclavicular and axillary regions which cannot readily be reached by the ear, are obvious, and need only to be mentioned to be appreciated.

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Donald M. Cammann.

STOMACH. The stomach is a dilatation of the intestinal tube, and forms the connection between the œsophagus and the duodenum. In the adult it is a pyriform sac, concave on its upper border (lesser curvature), and convex on its lower (greater curvature). The œsophagus enters its upper part at the distance of about one-fourth or one-fifth of its long diameter from the left extremity (cardiac orifice). The portion to the left of the cardiac orifice is called the fundus. From the cardiac orifice the stomach tapers until it merges into the duodenum. The

outlet of the stomach is marked externally by a constriction (pylorus). A short distance from the pylorus is a narrowing, more marked above than below, which indicates the boundary of the *antrum pyloricum.*

Occasionally a second constriction is found near the middle of the stomach.

The cardia lies behind the sixth and seventh right costo-sternal articulations; the pylorus between the tip of the ensiform cartilage and the edge of the ribs. The lesser curvature lies along the left edge of the vertebral column. The greater curvature, beginning a little to the left of the sixth costo-sternal articulation, rises to the fourth intercostal space, lying at this point above the apex of the heart; thence it goes downward and to the left in a nearly circular direction until it reaches the lower border of the seventh rib, then continues its course to the right until it reaches the middle of the epigastrium, and finally rises to the edge of the floating ribs, on a level with the tip of the ensiform cartilage. The diaphragm rests upon the greater part of the left segment of the stomach. The fundus touches the spleen and left kidney. The pancreas, with only the omentum and splenic artery and vein intervening, rests against the lesser curvature and the body. Behind this again is the great solar plexus of nerves and the cœliac axis. The pyloric end of the stomach is covered by the liver; the greater part of the lower border of the greater curvature rests upon the transverse colon (Fig. 3722).

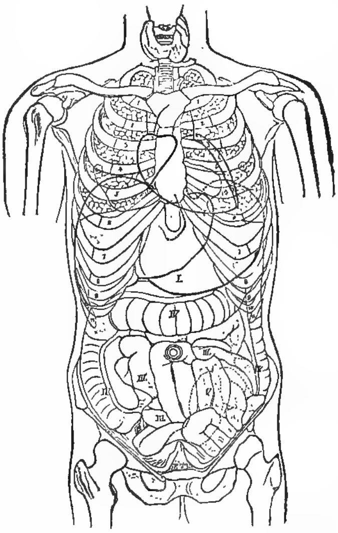

FIG. 3722.—View of the Abdominal Organs from in Front. (From Ranney, after Luschka.) The numerals are placed upon the respective ribs: I., the stomach; II., duodenum; III., ileum; IV., colon; V., sigmoid flexure.

In infancy the stomach is more fusiform in shape, and its direction is more perpendicular, than in adult life.

The position is said to change when the stomach is distended, the greater curvature being carried forward and upward, the anterior surface being raised and the posterior depressed. This change in position has, however, been denied by some.

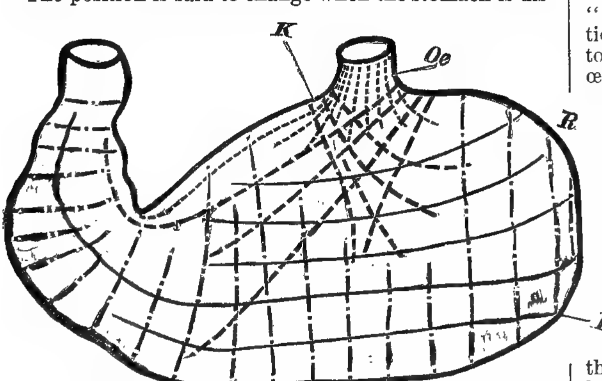

FIG. 3723.—Outline of the Stomach, showing Constriction of Antrum Pyloricum and Direction of Muscular Fibres. R, Circular muscular layer; L, longitudinal muscular layer; Oe, radiation of œsophageal fibres; K, saddle-like bundles.

When full, the stomach is from ten to twelve inches in length, and at the boundary of the fundus, the broadest part, it is from three to four inches in breadth. From this point it diminishes until it is only one inch in diameter at the pylorus. Its capacity is from five to eleven pints (Henle). The thickness of the walls, which increases toward the pylorus, varies according to the degree of muscular tonus, the average being from 2 to 3 mm. ($\frac{1}{12}$ to $\frac{1}{8}$ inch). The weight is about four and a half ounces in the male; it is less in the female.

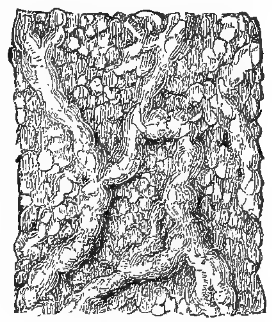

FIG. 3724.—Mammillated Appearance of the Mucous Membrane of the Stomach. (Henle.)

It is composed of four layers: serous, muscular, submucous, and mucous.

The *serous, outer, layer* was derived originally from the peritoneum. A double layer passes from the liver to the lesser curvature of the stomach (the gastro-hepatic or lesser omentum). At the stomach it splits, and one layer passes in front and the other behind. At the greater curvature these layers unite again, to form the great omentum. To the left of the cardia, a fold similar to the lesser omentum passes between the diaphragm and stomach (the gastro-phrenic ligament).

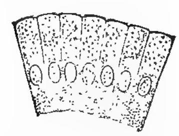

FIG. 3725.—Epithelium of the Mucous Membrane of the Stomach; fresh. (Heidenhain.)

The *muscular coat,* of smooth muscular fibre, consists of three layers—longitudinal, circular, and oblique.

The longitudinal fibres are in direct continuity with those of the œsophagus. Some of the œsophageal fibres are lost at the cardia; of the remainder a thick layer passes along the lesser curvature to the pylorus, another bundle of fibres passes along the greater curvature, and others radiate from the cardia. Two "saddle-like collections of fibres," one to the right of the œsophagus and radiating to the left, the other to the left of the œsophagus, radiating to the right, form a sort of sphincter around the orifice; the latter bundle, the thicker, reaching as far as the *antrum pyloricum.*

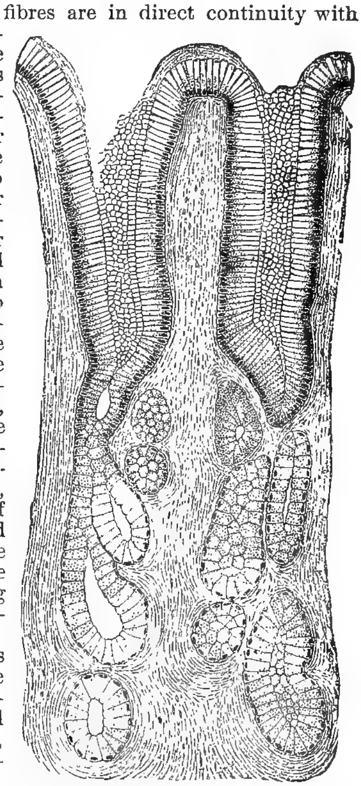

FIG. 3726.—Glands of the Stomach. From the neighborhood of the pylorus. (Ebstein.)

The circular is the most complete layer. At the pylorus it is thickened into a sharp ring, which forms the pyloric sphincter.

The inner, oblique, layer is the continuation of the inner circular fibres of the œsophagus. It spreads over the interior of the stomach to the left of the cardia, in a direction to form an oblique angle with

the axis, to the pylorus, and gradually loses itself on the two sides (Fig. 3723).

The submucous layer is composed of loose connective tissue, and serves as a bed for the net-work of blood-ves-

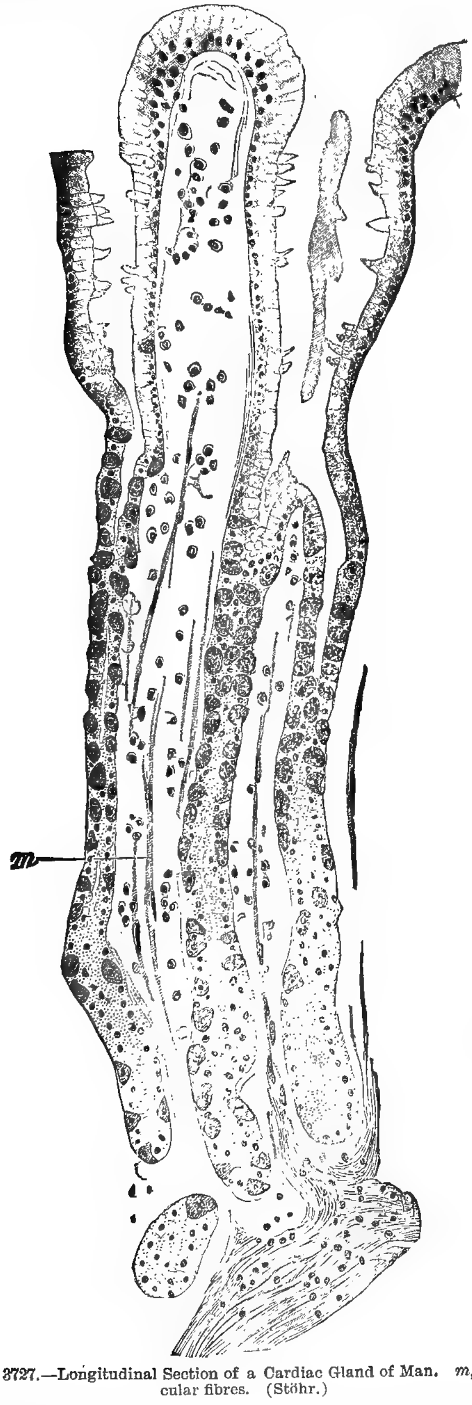

Fig. 3727.—Longitudinal Section of a Cardiac Gland of Man. *m*, Muscular fibres. (Stöhr.)

sels and lymphatics which supply the mucous membrane.

The *mucous membrane* is soft and pulpy, and is in marked contrast with the shining membrane of the œsophagus, from which it is separated at the cardia by a sharp zigzag line.

The color varies with the age of the individual. In the infant it is pink, but becomes reddish-gray and gray as age advances.

When the stomach is empty the contraction of the *muscularis mucosæ* throws the mucous membrane into folds (*rugæ*) which lie, for the most part, in a longitudinal direction. The rugæ are obliterated when the stomach is distended.

Between the rugæ run minute furrows, which divide the surface into rounded eminences flattened at the top (mammillations); they are from two to three mm. ($\frac{1}{12}$ to $\frac{1}{8}$ inch) in diameter (Fig. 3724).

Besides the mammillations there are also elevations caused by the presence of the agminated glands.

The stomach is very vascular. The *arteries* are derived from the cœliac axis, branches passing to each end of both the upper and lower curvatures. Here they penetrate beneath the peritoneum and anastomose, to form two vessels which run the length of the curvatures, one above and the other below. These vessels divide the organ into equal halves.

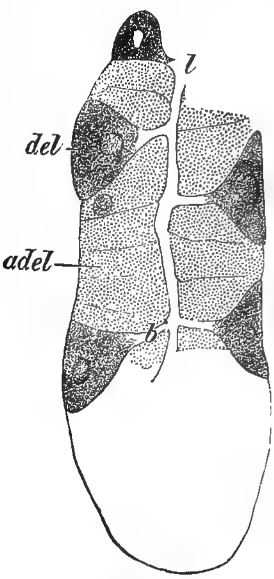

Fig. 3728.

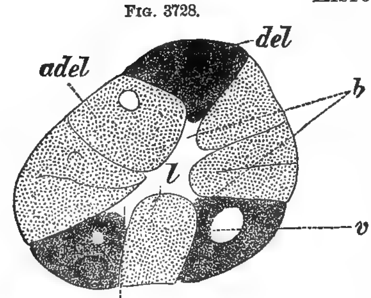

Fig. 3729.

Figs. 3728 and 3729.—Longitudinal and Transverse Sections of a Gland from the Fundus of the Human Stomach. The transverse section is made near the base of the gland. *l*, Lumen; *v*, vacuole; *del*, delomorphous, and *adel*, adelomorphous parietal glands; *b*, prolongations of the delomorphous cells. (Stöhr.) × 600.

The *veins* accompany the arteries and have essentially the same course, but they are of larger calibre, fewer in number, and less complex.

The *lymphatics* also follow the course of the blood-vessels, to form a plexus in the submucous connective tissue from which the lymphatic capillaries arise.

Lymphatic glands are found in the course of the lymphatic vessels along the two curvatures.

Histology. — *The serous layer* is 0.03 mm. in thickness, and resembles the peritoneum in microscopic character.

The muscular layer is composed of smooth muscular fibre.

The submucous layer is composed of loose connective tissue, with a few fat-cells.

The mucous membrane, however, is the layer of special interest, both histologically and physiologically. A perpendicular section shows the membrane to consist of an epithelial layer separated by a basement membrane from a muscular layer (*muscularis mucosæ*).

The *epithelium* is of the columnar variety, and presents a sharp contrast to the flat epithelium of the œsophagus. The cells are long and slender, and are filled with granules. They contain near their centre a large, oval nucleus. "Goblet-cells" are sometimes found. Scattered among these are rounded cells, sometimes in nests (Fig. 3725).

The surface epithelium dips down at short intervals to form the mouths of the gastric glands. These glands begin at the cardia and extend to the pylorus. They lie so thickly together that, in a transverse section, the mucous membrane appears striated, and seems to be wholly

Stomach.

composed of them. They extend through the membrane and rest upon the muscular layer beneath. The glands, at first sight apparently all alike, are, upon closer examination, found to be of two classes: those found near the pylorus (pyloric glands), and those found near the cardia (cardiac glands).

The *cardiac glands*, formerly called peptic glands, are longer and more complicated than the pyloric. They consist of a cylindrical tube, which gives off at its lower extremity three or four branches.

The upper and broader tube is lined by cells which resemble the cells of the mucous membrane, except that they are perhaps a trifle smaller. Lower down in the tube the cells become shorter and slightly broader, and at the point where the branches are given off they are, in a longitudinal section, nearly square (cubical cells). From this point they broaden, and toward the bottom of the gland become irregular in outline. Lying next the basement membrane, and covered by the irregular cells, is a fourth variety of cell—the parietal cell — sometimes called peptic cell. These cells are ovoid in shape and much darker than the others. When swollen they nearly touch one another. Two to four are usually seen in a section of the gland parallel to the surface of the stomach. The net-work described by some observers in these cells has not been demonstrated.

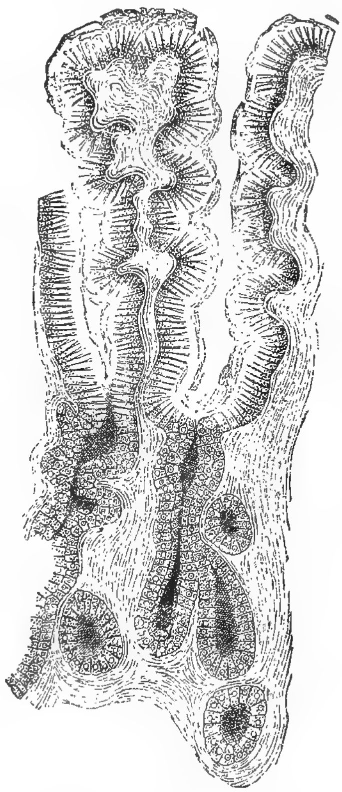

FIG. 3730.—Glands of the Stomach, from the Neighborhood of the Pylorus, showing the Changes occurring during Digestion. (Ebstein.)

The *pyloric glands* resemble the cardiac glands in general appearance, but their upper portion is broader, and the branches at the bottom are shorter and fewer in number. They contain only the first and second varieties of cells. The two kinds of glands shade gradually one into the other.

The number of glands in a square millimetre ($\frac{1}{25}$ inch) is about one hundred. In the whole stomach there are about forty-nine thousand (Henle) (Figs. 3726, 3727, 3728, 3729). The depth of the first part of the glands "in the normal stomach is, at the cardia, about 0.2 mm. (.0079 inch), but toward the pylorus it increases in a marked degree. The transverse diameter, including the epithelium, is about 0.07 to 0.10 mm. (.0028 to .004 inch), of which about 0.05 mm. (.002 inch) is included in the height of the epithelium. The height of the epithelium is 0.025 mm. (0.001 inch). The passages average 0.02 mm. (0.008 inch) in breadth; exceptionally they are 0.06 mm. (.024 inch)" (Henle).

The basement membrane bounds the epithelium of the stomach and its glands. It is a membrane composed of flattened cells, which send out prolongations among the epithelial cells of the mucosa and of the glands.

The muscularis mucosæ is better developed in many of the lower animals than in man. It consists of two layers of smooth muscular fibre, an outer circular, and an inner longitudinal, layer. From the inner layer prolongations are sent up among the glands.

A use for these prolongations in emptying the glands of secretion during digestion can be imagined.

The mucous membrane and glands present different appearances at different times. The cells of the mucous membrane in the intervals of digestion are slightly larger at the top than at the bottom, and are filled with a clear, muco-albuminous substance (mucigin, Schäfer) in which the granules are suspended. Consequently the tops of the cells appear more transparent and less granular than the bottom. During digestion the mucigin is discharged, carrying with it a considerable number of granules. After digestion, therefore, the cells become shorter and more opaque. During digestion the glands of both kinds discharge granules. The parietal cells of the cardiac glands at this time swell to nearly double their size; they resume their original appearance after digestion is completed (Fig. 3730).

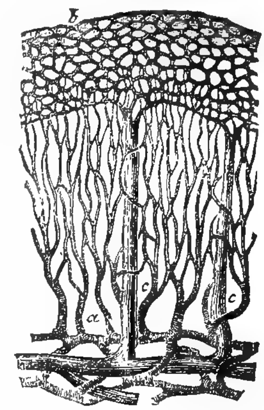

FIG. 3731.—Plan of Blood-vessels of the Stomach. *a*, Arteries; *b*, rings around the mouths of the glands; *c*, veins. (Quain.)

At the pyloric orifice is a ring of *racemose glands* which resemble the duodenal glands.

Papillæ also begin to appear in the neighborhood of the pylorus, which are the beginnings of the papillæ of the small intestine and resemble them in structure. "These *plicæ villosæ* are about 0.05 mm. in height" (Henle). They are sometimes absent.

The *blood-vessels* of the stomach are arranged in a manner which differs from that in any other organ, except the colon. The arteries form a net-work in the submucous connective tissue. From this net-work large capillaries or arterioles arise, which pass upward between the glands, giving off in their course two or more branches which connect with the other upright arterioles, and form a mesh-work around each gland. At the upper part of the glands they empty into veins, which form rings around the mouths of the glands. They are of considerably larger diameter than the capillaries. They are con-

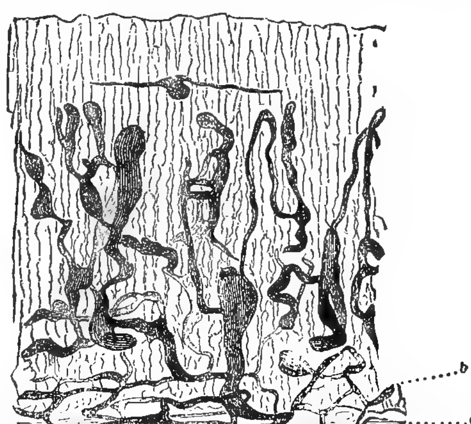

FIG. 3732.—Lymphatics from Human Gastric Mucous Membrane; injected. The tubules are faintly indicated. *a*, Muscularis mucosæ; *b*, plexus of fine vessels at base of the glands; *c*, plexus of larger valved lymphatics in submucosa. (Lovén.)

nected together in a network which empties into a large vein perpendicular to the surface.

In the submucous tissue, these veins empty into another venous plexus which conveys the blood away from the organ (Fig. 3731).

The *lymphatics* are also peculiar. A lymphatic plexus in the submucous connective tissue sends up branches which, as is usual with lymphatics, are very irregular in size and length. In the main they run upward, inosculate with other branches, and end apparently in a blind tube (Fig. 3732).

Lymphatic structures resembling the so-called solitary glands of the small intestine are found scattered throughout the stomach. These are less perfectly separated from the other structures than are the solitary glands. They consist of a reticular structure filled with lymphoid cells. Toward the periphery the reticulum becomes coarser, the cells are fewer, and finally disappear without any line of demarcation. These structures are most abundant in childhood, after which they become fewer, and finally disappear after middle life.

The nerves form gangliated plexuses similar to those of the small intestine. In the muscular layer is a plexus similar to Auerbach's plexus. In the submucous layer is one similar to Meissner's plexus. The termination of the nerves is unknown. *Lester Curtis.*

STOMACH, ORGANIC DISEASES OF THE. Gastritis.—Although there is no distinct dividing line, as regards morbid anatomical changes, between subacute and acute inflammation of the stomach, it is necessary to distinguish clinically between these two grades of gastric disease, because they differ essentially, in symptomatology, in prognosis, and in treatment; while typical cases also present decided points of diversity in their respective pathological anatomical conditions. The writer, therefore, proposes to describe under their combined titles, first, the milder, and then the graver types of gastritis, believing that their juxtaposition will render more apparent both their resemblances and their points of dissimilarity.

I. Subacute and Acute Gastritis. *Etiology.*—The causes of these diseases are predisposing and exciting.

(a) *Predisposing Causes.*—The predisposing, or indirect causes are so similar for both subacute and acute gastritis that a separate enumeration for each disease seems unnecessary, while the exciting, or direct causes differ rather in degree than in kind. The predisposing causes are all conditions, whether general or local, which temporarily impair the vitality of the gastric tissues, thus reducing their power of resisting irritation, and their capacity for the performance of their respective functions. The constitutional conditions favoring subacute and acute gastritis are, thus, transient anæmia and asthenia from whatever source. We accordingly see a predisposition to these diseases in febrile affections, such as typhoid and typhus fevers, diphtheria, the eruptive and malarial fevers, acute rheumatism and gout; while in those persons who are naturally weak, even slighter ailments, such as bronchitis, pharyngitis, or influenza may predispose to these diseases. The predisposing influence of these febrile conditions is readily accounted for by the accompanying diminution in the secretion of saliva and gastric juice, and by the consequent retardation and perversion of digestion. If, in these febrile states, food be administered in such quantity or be of such a quality as to overtax the digestive powers of the stomach, fermentation will ensue and lead to the production of irritating acids and gases. Besides exerting a harmful chemical action upon the gastric mucous membrane, the gases over-distend the organ, thus still further enfeebling its muscles, the contractile power of which has already been impaired by pre-existing systemic weakness. The decomposing mass thus remains, for an indefinite period, in contact with the mucous membrane, constituting one of the exciting causes of gastritis to be presently enumerated.

The use of certain drugs, in disease or in health, may strongly predispose to gastritis, by diminishing the secretion of the digestive fluids and by retarding the peristole of the stomach. Among these medicines may be mentioned opium and its derivatives, belladonna, stramonium, hyoscyamus and cocaine. Chloral, the bromides and other spinal depressants probably exert a similar influence. Local diseased conditions of the stomach and of other organs likewise favor the development of gastritis. To this class of causes belong gastrectasia, whether obstructive or atonic, ulcer, new-growths in the stomach and congestion. Venous congestion of the stomach is produced by obstruction to the portal circulation from many causes, among which the most obvious are weakened heart action, pulmonary and pleuritic diseases obstructing the pulmonary circulation and hepatic diseases preventing the normal discharge of blood from the portal vein. Repeated attacks of gastritis predispose to relapses of the disease by their deleterious influence upon the vitality of the mucous membrane and, perhaps, by impairing the tone of the gastric vessels.

Children are more susceptible than adults to the action of comparatively feeble gastric irritants, because of the inherent sensitiveness of their mucous membranes. Old people, convalescents, and anæmic patients are likewise particularly predisposed, because of their low vitality and of the consequent slight resisting power of their tissues. Asthenia and anæmia from chronic diseases, on account of their more lasting influence, rather predispose to chronic than to subacute and acute gastritis. These chronic diseases will, accordingly, be mentioned under the etiology of chronic gastritis. It is, however, to be remembered that these disorders may, in their inception, lead to transient attacks of subacute and of acute gastritis, which diseases may also be invited by the imposition of unusual digestive tasks upon a stomach ordinarily accustomed to a simple and restricted diet.

(b) *Exciting Causes.*—The exciting causes of subacute and acute gastritis are thermal, mechanical, or chemical irritants. To the first class belong ice-cold, as well as overheated fluids and solids. Mechanical irritation of the stomach may be produced by abdominal contusions, the careless or frequent introduction of hard-rubber stomach-tubes, and the ingestion of sharp, rough, or indigestible solids, or of coarse, uncooked, or superfluous foods. Among the most important chemical irritants are the gases and acids resulting from putrefactive and other fermentative processes in the stomach, too highly seasoned and too acid foods, undiluted alcoholic beverages, as spirits and cordials, drastic cathartics, other irritating drugs, urea and carbonate of ammonia eliminated by the stomach in Bright's disease, and various corrosive poisons, as mercury, arsenic, zinc, nitric acid, sulphuric acid and oxalic acid. Alcohol and the corrosive poisons are chiefly responsible for the most severe cases of acute gastritis, but any of the above-named irritants may act as efficient exciting causes of the disease in an organ already predisposed to inflammation. Most authors mention exposure to cold as a possible exciting cause of gastritis, but regard its etiological influence as problematical. Violent physical exercises, powerful intellectual efforts, or strong emotions, may act as exciting causes of subacute gastritis by arresting digestion, and thus favoring fermentation. In these cases the arrest of secretion may be the effect either of nervous inhibition, or of diversion of blood into other channels, or of both these conditions combined.

Morbid Anatomy.—Opportunities for the *post-mortem* observation of the pathological anatomical changes in subacute gastritis are rare, because the disease tends, almost invariably, to recovery, and such examinations, when obtained, are necessarily misleading because vascular contractions, occurring after death, may quite obliterate the traces of the inflammatory process. On the other hand, *post-mortem* injection and softening of the mucous membrane, or auto-digestion of the gastric walls, may confuse the pathologist. The recorded cases of subacute and acute gastritis in which *intra-vitam* observations have been made upon men and animals, therefore, possess a peculiar importance, and the classical case of Alexis St. Martin, minutely studied by Beaumont, is regarded as the most valuable and reliable source of information in regard to this subject. The gastric mucous

membrane of St. Martin, when moderately inflamed by alcohol or other irritants, presented, according to Beaumont, a mottled appearance, pale areas intervening between small and irregularly shaped spots of a red or bluish-red color. Other spots, white, apparently elevated above the surrounding membrane and resembling patches of false membrane, were sometimes present. The gastric juice was notably diminished in quantity, while the mucus was increased; and when the inflammation was more severe, pus was also abundantly produced. Small venous hæmorrhages occasionally took place from the congested areas, and ecchymoses were also observed.

In *acute gastritis* autopsies are more frequently made and the pathological conditions are consequently better understood than in subacute gastritis. In these cases the mucous membrane, particularly that of the pyloric region, is more opaque than in health, and may present alternating red and pale areas. Sometimes, however, the whole surface is pale, and again, it may be uniformly congested. The membrane is softened, thickened, sometimes ecchymotic, often ulcerated and covered with thick, adhesive mucus or muco-pus, which is sometimes stained with blood, and contains desquamated cylindrical epithelial cells. The ecchymoses and ulcerations are most frequently seen at the apices of the folds in the mucous membrane. The submucous tissues are sometimes swollen and either red or pale. The microscope shows the capillaries of the reddened areas in the mucous membrane to be distended with blood, and this is especially true of the vessels in close proximity to the orifices of the gastric tubules. The ecchymoses present the usual microscopic appearances. The base of the ulcers is sometimes composed of extravasated blood, and sometimes of the submucous tissues. Ecchymoses are also found between the tubules, besides serum, either limpid or blood-stained, and pus. The submucous tissues may be infiltrated with serum and pus. The gastric solitary follicles are, when present, occasionally hypertrophied, and sometimes numerically increased. The lining cells of the mucous membrane are swollen and their desquamation is probably abnormally increased. Great interest centres about the pathological changes in the secreting cells of the gastric tubules. These may remain normal, but they often undergo parenchymatous, and subsequently fatty, degeneration, being thickened, in these respective conditions, by abundant albuminous or fatty granules, and presenting a whitish, opaque appearance. The tubules are sometimes partly filled by cells of this description, and sometimes with amorphous and granular matter. In the most *acute forms of gastritis*, such as are produced by corrosive poisons, false membranes may be developed in the mucous membrane, and sloughing of this membrane and of the deeper tissues may ensue, leading to perforation of the stomach. Many of the above-mentioned morbid anatomical changes are often simultaneously found in the stomach and the duodenum, the disease being then known as gastro-enteritis.

Clinical History. (*a*) *Constitutional Symptoms.*—Subacute gastritis presents the familiar train of symptoms collectively known as acute indigestion, by French authors as *embarras gastrique*, and in popular parlance as a "bilious attack." The symptoms naturally vary within wide limits, in accordance with the severity of the inflammation. The following description aims at reproducing the clinical picture presented by a case of medium severity. In such a case there is loss of appetite, generally repugnance to food, often nausea, sometimes emesis, and occasionally a longing for highly seasoned foods and for condiments or spices. The vomited matter contains the offending material which caused the attack, unless this has already passed into the intestine, mucus, sometimes bile and, more rarely, a little blood. The bowels are generally constipated, but sometimes are relaxed. If diarrhœa is present, enteritis probably exists. Eructations and flatulence are common. The urine is scanty, high-colored, charged with urates, and sometimes contains oxalate of lime, leucine, and tyrosine. Headache is a frequent, but not a constant, symptom; occasionally it is very intense and may then be due to auto-infection with septic materials resulting from fermentation in the stomach. In this connection it is interesting to recall the cases reported by Litten, in which he observed, besides headache, nervous restlessness, great muscular weakness, and finally, marked somnolency. In these cases the expired air had a decidedly fruity odor and the urine showed the reaction now usually referred to the presence of diacetic acid, viz., a bright red-color upon the addition of a solution of the chloride of iron. In some cases the eructations have the odor of sulphuretted hydrogen, but often they are odorless. The mental energy is impaired, the spirits are depressed, and there is ordinarily a sense of physical fatigue or of prostration out of all proportion to the real loss of power. There may also be vertigo and partial aphasia, *tinnitus aurium*, faintness and dyspnœa. The pulse is generally quickened and the temperature raised, but not commonly above 100° or 100½° F. Exacerbations of fever may occur toward evening and after the ingestion of food. In milder cases there is sometimes no febrile movement, the pulse remaining infrequent and feeble, and the surface cold. Chilly sensations and even chills may occur.

(b) *Local Symptoms.*—The mouth is dry, the breath foul, the tongue coated at first, and, later, sometimes red or glazed. There is epigastric tenderness and prominence, generally accompanied with a constant dull pain and a sensation of tension in the stomach. This feeling of repletion is sometimes relieved by emesis or by eructations. The above-named sensations are all intensified by the introduction of food, unless it be cool and liquid. The gastric muscles being relaxed or paretic from overstretching, the food remains undigested in the stomach for a long time, unless removed by vomiting or catheterization. Intermittent, acute pains, resembling those of intestinal colic, often occur, while pyrosis and gastric tympanites are not uncommon. Patients frequently complain of a bitter taste in the mouth. Slight icterus sometimes appears, as a sign of gastro-duodenitis. Labial herpes and urticaria are occasional symptoms. Mild cases of subacute gastritis are usually of only a few days' duration. In more severe cases the inflammation may persist for one, two, or even three weeks. If the disease be still more protracted, it is regarded as constituting chronic gastritis (*quod vide*). When subacute gastritis develops in conjunction with gastric dilatation, the symptoms are more likely to be severe and protracted than in subacute inflammation of a previously healthy stomach. The contents of the stomach are retained for a greater length of time, and fermentation ensues with greater rapidity. The cerebral symptoms are correspondingly intensified, whether from reflex irritation or from auto-infection by means of ptomaïnes. Gastric tympanites and epigastric tenderness are apt to be more marked than in healthy stomachs, but paroxysmal pain is less frequent on account of the flaccidity of the dilated organ. Obstinate constipation is the rule, because the gastric contents pass through the pylorus in very small quantities and their fluid parts are completely absorbed in the small intestine. Prostration is sometimes extreme in these cases. In young children subacute gastritis causes more intense febrile movement, more marked depression, and more serious symptoms, in general, than in adults. It is difficult to elicit exact information from the little patients regarding their subjective symptoms, but the objective phenomena and physical signs are essentially the same as in grown people. Entero-colitis is likely to associate itself with the gastritis in young children, particularly in hot weather, thus constituting the disease popularly known as "cholera infantum," for a description of which the reader is referred to the article in this HANDBOOK treating of that subject.

In *acute gastritis*—which term is here applied to that serious form of gastric inflammation ordinarily caused by immoderate indulgence in alcoholic drinks, or by the action of corrosive poisons—the symptoms and signs are striking, characteristic, and, in serious cases, truly appalling. The first symptom, in cases of great severity, is generally intense burning epigastric pain, accompanied by great tenderness on pressure, and by rigidity of the

abdominal walls. Even the respiratory diaphragmatic movements augment this pain. If the attack is occasioned by caustic substances, there is also pain and burning in the mouth, pharynx, and œsophagus, dysphagia and sometimes aphonia. Nausea, with violent and very painful acts of emesis, soon follows, the matter rejected from the stomach containing portions of the poisonous material, saliva, and often either liquid or grumous blood. The stomach is so irritable that any substance, no matter how bland or how small in volume, is instantly rejected. Even cool water, in teaspoonful doses, is not retained. The thirst is intense and the bowels are constipated, unless some violent irritant has entered the intestine, when there may be active and painful purging. The urine is almost or quite suppressed. There is often violent headache, but the intellect is unimpaired. The face is haggard and expresses fright or apprehension. In the advanced stages of fatal cases the eyes are sunken, the features pinched, and the color ashen. The pulse is frequent and compressible. The temperature is at first elevated, sometimes to a point between 102° and 103° F., but is, later, depressed. The respirations are frequent, superficial and irregular. The surface is at first hot and dry, and later is cold. Sometimes there is icterus from involvement of the duodenum. In cases ending in recovery, gradual amelioration of all these symptoms occurs. In fatal cases asthenia ensues, ending in collapse, which quickly closes the scene. If perforation of the stomach occurs, fatal shock follows, or, if the patient survive the shock, peritonitis causes a lethal issue.

Differential Diagnosis.—The diagnosis is generally easily made. Remittent or typhoid fever of slight severity may be mistaken for subacute gastritis, but the reverse error is more likely to occur, particularly in the case of children. Gastritis is often produced by any febrile disease which arrests the secretions and invites fermentation. Under these circumstances, care must be exercised lest one or the other ailment be overlooked. An examination of the spleen and of the blood, and the use of the thermometer, may decide the question by revealing the absence or presence of conditions characteristic of malarial or of typhoid fever. Leube considers the presence of herpetic vesicles as quite characteristic of gastritis.

Chronic meningitis may simulate subacute gastritis, especially in young subjects, being attended with frequent vomiting, which is, however, explosive and not accompanied by nausea, or by epigastric tenderness. There is, moreover, obstinate constipation in meningitis, while gastritis in children is usually complicated by enteritis, which causes diarrhœa. In the early stages of meningitis the pulse is rather diminished in frequency than accelerated, while the reverse obtains in gastritis. In meningitis there are jactitation and intolerance of light and sounds.

Prognosis.—Subacute gastritis almost invariably ends in recovery, or at most, in badly managed cases, may terminate in chronic gastritis. Acute gastritis, from corrosive poisons, is commonly fatal from collapse or shock. Alcohol in excessive quantities often produces the same result, particularly in cases attended with asthenia from repeated debauches.

Various complications of acute gastritis may contribute to the fatal issue. Chief among these are peritonitis from gastric perforation: the effect on the nervous system, independent of their local action, of some corrosive poisons, like arsenic; œdema glottidis, and enteritis. As sequelæ, may be mentioned gastrectasia, from fibroid constriction following ulceration of the pyloric orifice, and œsophageal obstruction from the same cause.

Treatment.—The indications for treatment, in subacute gastritis, are to remove irritating substances from the stomach and to prevent the ingestion of such articles; to allay the irritation of the mucous membrane, and to temporarily procure for the organ partial or complete relief from the performance of its functions. The measures adapted to meet these indications will vary with the severity of the gastric inflammation. In the mildest cases, nothing is required beyond a reduction of the diet to the minimum quantity consistent with adequate support of the patient, and the exclusion of all irritating foods. Peptonised milk, or milk and Vichy water, in equal parts, with toast or toasted crackers, may be given, in six- or eight-ounce doses, at intervals of three hours. The writer is in the habit of prescribing a powder containing from three to eight grains of sodium bicarbonate and from ten to thirty grains of bismuth subcarbonate, before each drink of milk and Vichy water, or of peptonised milk. The former ingredient is intended to neutralize abnormal acids which may have been formed in the stomach as the result of fermentations, and the latter to soothe the irritated mucous membrane. If there be physical evidences of prolonged retention of food in the stomach, an unirritating laxative, as Hunyadi Janos water, citrate of magnesia, or a seidlitz powder, may be administered at the outset. If there be jaundice, a few grains of calomel may be given and followed, in a few hours, by the saline laxative. In subacute gastritis complicating gastrectasia, the writer has had good results from the gentle use of the soft syphon-tube, according to the method described in the section which treats of Gastrectasia. By lavage, irritating matters are at once withdrawn, and the proper dietetic measures are, subsequently, doubly efficacious. Daily laxative enemata are also to be recommended, besides demulcent drinks, in small quantities, between the doses of milk.

In more acute gastritis, attended by considerable vomiting and febrile disturbance, the ingestion of aliment is to be still farther restricted, or even suspended, for a few hours or days. In these cases nature has generally fulfilled the first indication for treatment, viz., the removal of irritating substances, as is proven by the rejection of simple mucus or of bile, occasionally mingled with blood. Here no evacuant is necessary, and neither emetics nor the syphon-tube are permissible. In acute gastritis complicating atonic gastrectasia, however, the tube may still be employed, as the dilated stomach can be quickly relieved of its irritating contents by this means alone, and enteritis from decomposed foods is, also, thus avoided. The first duty of the physician, in these cases, is to allay gastric irritability, which may generally be effected by placing the patient in bed, withholding all food and drink, applying a sinapism or blister to the epigastrium, and by administering morphia, in doses of one-eighth or one-fourth grain, either dry upon the tongue, or dissolved in a teaspoonful of water. If this be rejected, the vomiting may be controlled by a moderate dose of morphia, given hypodermatically or by the rectum. In all but the most severe cases, small bits of ice, given every few minutes, are very grateful to the patient, mitigating his thirst and cooling the inflamed stomach. Sponging the surface of the body with tepid water also allays thirst and fever. If, however, even the ice-water be not retained, urgent thirst may be relieved by rectal injections of lukewarm water, preceded by a laxative enema. Laudanum, given in the water by rectum, obtunds the sensibility of that viscus, thus favoring the retention of the water, and also controls the gastric tenesmus, the pain, and the emesis. This method of administering the opiate is to be strongly recommended whenever the hypodermatic use of an opiate is objectionable. When the vomiting has been so far controlled that cracked ice is tolerated and may be relied upon to assuage the thirst, or before this time, if the patient be in urgent need of nourishment and support, nutritive enemata may be given instead of those composed of pure water, or of water and opium. It is under these circumstances that rectal alimentation renders its most striking and signal services. The enemata are not to exceed five ounces in quantity, and are to be given every four or six hours. Peptonised milk is, in the writer's opinion, the aliment best adapted for administration by the rectum, as it is practically digested and need only be absorbed by the bowel. Leube's meat solution, as modified by Rosenthal, and defibrinated blood, and Rudische's beef peptonoids, are also of great value. Even sweet milk, to which the white of an egg has been added, given with pepsin and pancreatic extract, is of undoubted service. A few drops of laudanum, added to each enema, prevent the development of rectal tenesmus

and exert a desirable tranquillizing influence. Alcohol may be added, if necessary, for purposes of support, and is particularly useful in asthenic cases of alcoholic gastritis. Laxative enemata are required, once or twice a day, to clear the bowel of undigested matters. When the stomach will tolerate food, the peptonised milk, or the milk and Vichy water, are to be given in small quantities, tentatively, next the carbo-hydrates and fats, and finally, after some days, the solid proteids.

The treatment of toxic gastritis, due to corrosive poisons, has been considered under the heading Poisons, Corrosive, and claims only a passing notice in this place. The first therapeutic measure indicated in these cases, is the prompt administration of such antidotes as are indicated, and, next, the expulsion from the stomach of the poisons. The poisons may be best removed by the soft stomach-tube, to which the stomach-pump may be attached in case of necessity. After the withdrawal of the toxic substances, appropriate emollients and sedatives are in order. The subsequent treatment is identical with that of ordinary acute gastritis. During convalescence from subacute or acute gastritis, great care should be taken to adapt the foods to the capacity of the enfeebled stomach, lest chronic gastritis or atonic gastrectasia be developed. The early use of tonics and of stimulants is contra-indicated on account of their irritating action. The appetite will generally be restored by nature, *pari passu* with the ability to digest substantial nourishment, but a feeble digestion may well be assisted by five grains of pepsin, and fifteen or twenty drops of dilute hydrochloric acid, given in water, an hour after each meal.

II. Chronic Gastritis. *Etiology.*—Most cases of chronic gastritis have their origin in antecedent subacute or acute gastritis, their causes being essentially the same as those of the latter forms of gastric disease. Some of the etiological agents of gastritis are, however, more prone than others to occasion chronic gastritis, because their influence is more protracted. This is true of all chronic, wasting diseases, and of all sources of chronic malnutrition which, by occasioning anæmia, gastric atony and, probably, degeneration of the gastric vessels, interfere with the normal secretion of the gastric juice, enfeeble the muscular coats of the stomach, and thus invite inflammation. In this category belong phthisis, cancer, gout, chronic nephritis, syphilis, rheumatism, chronic malarial disease, neurasthenia, rigid dieting, long fasting and old age. All causes of protracted obstruction to the portal circulation tend to produce chronic gastritis, by maintaining a venous congestion of the stomach. This group of causes, in which all diseases obstructing the pulmonary circulation are prominent members, has been sufficiently considered under the etiology of subacute and acute gastritis. Men suffer more frequently than women from chronic gastritis. Fenwick and Strümpell believe in the existence of a hereditary tendency to chronic gastritis. Among the exciting causes of chronic gastritis are to be particularly emphasized repeated over-indulgence in foods, whether digestible or comparatively indigestible, the habitual use of over-stimulating aliments, imperfect mastication, and alcoholic excesses, or even the use of moderate quantities of alcohol when the stomach is empty. Even perfectly simple food, in proper quantities, may cause chronic gastritis in an enfeebled stomach, or in one still feeling the effects of antecedent inflammation. Another exciting cause is the abuse of irritating drugs, such as cathartics and tonics, or of medicinal substances which diminish the secretions and retard gastric peristole, as opium and cocaine. Many gastric diseases either predispose to chronic gastritis or excite it. Among these diseases are gastrectasia, suppurative gastritis, cancer and ulcer.

Morbid Anatomy.—The stomach, when affected by chronic inflammation, may be either normal in size, dilated, or smaller than in health. The pyloric region of the stomach is generally the seat of the most marked pathological changes. The mucous membrane is commonly abnormally vascular, and covered with a deposit of thick tenacious mucus, or of thinner muco-pus containing epithelial cells. The membrane may be thickened or thinned. In the earlier stages, there is more frequently general thickening and opacity, while diffuse thinning and transparency correspond to the atrophic changes of a later period in the disease. Thickening and thinning often, however, coexist, producing, by their combination, alternating prominences and depressions in the mucous membrane. This is the condition to which the name *état mamelonné* was given by Louis. Diffuse thickening of the pyloric mucous membrane may occasion stenosis of the pylorus, followed by gastrectasia. Small cysts, produced by the distention of obstructed gastric follicles with a clear fluid, are often observed, and, more rarely, polypi composed of hypertrophied connective tissue and hyperplasia of the gastric tubules. The consistency of the mucous membrane is, in some cases, increased, and in others diminished. The membrane is rough when thickening coexists with thinning, but it may be smooth when extensive atrophy exists alone. The color of the mucous membrane may be white, ashen, red, reddish-blue, slate-colored, reddish-brown, or black. Ecchymoses and so-called hæmorrhagic erosions are not rare, and many of the above-mentioned variegated tints are produced by the more or less complete reabsorption of hæmoglobin. Little points of a darker hue than the surrounding membrane are found, on microscopic examination, to consist of pigment particles, either free or inclosed in cells, between or within the tubules. The microscope generally shows, in the thickened parts of the mucous membrane, dilatation of the vessels, proliferation of connective tissue, sometimes hypertrophy of the submucous and muscular coats, and enlargement with distention of the gastric tubules, from parenchymatous and fatty degeneration of their epithelium. In the thinner portions of the mucous membrane the vessels are of small calibre. Some of the tubules are diminished in size, being filled with granular detritus resulting from degeneration of the epithelium, and others are quite obliterated by the pressure of surrounding, new-formed connective tissue. The cysts alluded to above are also due to partial obstruction of the tubules by connective tissue and their consequent distention with their perverted secretion. W. Fox has observed fatty degeneration of the connective tissue in some cases of chronic gastritis. The gastric solitary glands, when present, are often hypertrophied.

Clinical History. — Given the morbid anatomical changes of chronic gastritis, the symptoms of the disease are referable to certain perversions in the functional activity of the stomach. Chief among these is the interference with the normal secretion of gastric juice. The effects of the diminution of this fluid are the retardation of digestion and the occurrence of butyric, lactic, acetic, or alcoholic fermentation. These fermentations do not occur in a healthy stomach, because the normal gastric juice is capable of destroying the living ferments which cause these retrograde changes in the food. The acids generated by these fermentative processes, being themselves irritating, add to the existing inflammation, while the gaseous products of the fermentations overdistend the stomach, and retard the peristaltic movements of that organ by inducing atony of the muscular coats. The free acid of the gastric juice is, moreover, held, by many writers, to be an essential stimulus to the gastric peristole, and the absence of the normal quantity of this acid may, accordingly, be unfavorable to the production of natural gastric contractions. Since successive contact of the food with all parts of the mucous membrane is essential to the due stimulation of glandular activity, the delayed peristole itself further indirectly reduces the amount of gastric juice, which is already diminished by glandular degeneration and atrophy. Another bad result of the impaired contractile power is the prolonged retention of the undigested contents of the stomach, by which fuller opportunities for decomposition are afforded. The gastric mucus, which, in chronic gastritis, is secreted in abnormally large quantities, hinders digestion mechanically, by coating the food with a comparatively impenetrable material, and chemically, since its alkalinity partly neutralizes the acid of the gastric juice. It is well known that the bulk of peptones elaborated in the stomach are,

under physiological conditions, directly absorbed from that viscus. Chronic gastritis greatly impairs absorption by causing inefficient muscular contractions, and, probably, by leading to degenerative changes in the gastric absorbent vessels. It has, moreover, been demonstrated that the presence of unabsorbed peptones directly retards the further transformation of proteids into peptones. The individual symptoms of chronic gastritis will be better understood and more readily interpreted, if these deviations from the regular course of physiological gastric digestion be constantly borne in mind.

The morbid phenomena of chronic gastritis may be classified as subjective and objective.

(*a*) Subjective Symptoms. A prominent subjective symptom is the loss or the perversion of appetite. Usually there is indifference and often absolute repugnance to food. Sometimes, however, there is a morbid craving for stimulating foods and beverages. When the inflammation is of a comparatively low grade, there may even be a moderate appetite, which, however, is succeeded by a sense of repletion after the ingestion of a small quantity of food or drink. Thirst is an almost constant symptom, and is, usually, most troublesome in the evening. Patients commonly complain of a bad taste in the mouth and of dryness of the buccal mucous membrane. There is, generally, persistent epigastric discomfort, burning, or oppression, which is accompanied by tenderness, is most marked after meals, particularly if the food be stimulating, and may at times be replaced by more or less acute pain. Eructations, either acid or tasteless, pyrosis, nausea, and vomiting are common, taking place, most frequently, soon after meals. In mild cases vomiting does not often occur, and it is an unusual symptom in chronic gastritis complicating atonic gastrectasia. With habitual drinkers, morning vomiting is common, and is known to the laity as *water brash*. Headache is a prominent symptom. It is generally frontal or temporal, and of a dull character. At times it becomes acute, lancinating, and even excruciatingly severe. The other leading subjective symptoms are vertigo, fatigue, disinclination for either physical or mental labor, and generally great depression of spirits, sometimes amounting to hypochondriasis. These nervous symptoms are all probably the joint effect of anæmic neurasthenia and of auto-infection with ptomaïnes. The bowels are constipated, unless there be coexistent entero-colitis, in which case there may be diarrhœa. Flatulence is common. Hæmorrhoids are caused by the constipation. The sleep is disturbed by restlessness and by distressing dreams. The urine is scanty and high-colored, or the reverse in cases of long standing. There may be cardiac palpitation and so-called "hot flashes," from temporary facial and cerebral congestion. This symptom chiefly occurs in women. Dyspnœa may be occasioned by the encroachment of a tympanitic stomach upon the thoracic space.

(*b*) Objective Symptoms. The patients are, as a rule, more or less emaciated and anæmic, their muscles being atrophic and their expression apathetic or melancholy. The skin is dry and of a grayish tint, unless there be icterus from concomitant duodenitis, which is not rare. The tongue is commonly pale, flabby, and covered with a whitish or a brownish-white coat, through which enlarged papillæ may sometimes be seen. The tongue is occasionally red and glazed. The borders of the tongue sometimes bear the impress of the teeth. Salivation is common. The gums are pale and swollen, the breath fetid. The pulse is normal in frequency or slightly quickened. In old people, the pulse may be remarkably slow and feeble. It is generally small and compressible; it may be irregular and intermittent. There is often slight fever, particularly during the exacerbations of the symptoms corresponding to intercurrent attacks of more acute gastritis. The urine is, ordinarily, of a high specific gravity and of dark color, and is frequently laden with amorphous urates. Uric acid and oxalate of lime are common urinary deposits, and the mucus is often abnormally abundant. On the other hand, the urine may, in cases of long standing, be of low specific gravity and of a pale color, its reaction being neutral or alkaline, and its sediment containing amorphous and crystalline phosphates. The epigastrium is generally sensitive to pressure, and is often distended. A succussion sound may sometimes be obtained, even in an undilated stomach. Caries of the teeth has been noted by some authors. Considerable interest attaches to the character of the matters spontaneously rejected, or artificially withdrawn from the stomach. The microscope shows these matters to consist chiefly of mucus, gastric epithelium, and remnants of undigested food, with the occasional admixture of blood, saccharomyces, sarcinæ ventriculi and various bacteria. The reaction of the contents of the stomach is generally acid, from the presence of either hydrochloric, butyric, acetic, or lactic acid. The existence of hæmorrhagic erosion may be suspected if much blood be vomited. The presence of lactic acid may be demonstrated by means of a test-liquid composed of ten cubic centimetres of a four per cent. solution of carbolic acid, twenty cubic centimetres of distilled water, and a drop of liquor ferri perchloridi. The blue color of this mixture is changed to yellow by free lactic acid. Strümpell recommends a solution of methyl violet as a test for hydrochloric acid, which turns this reagent blue, and the same author makes favorable mention of Uffelmann's test, which consists of the pigment derived from the common blueberry or huckleberry. This pigment is turned a bright-red by free hydrochloric acid. The so-called "water-brash," rejected by habitual drinkers, is usually alkaline, and probably partly consists of saliva swallowed during sleep. In the chronic gastritis secondary to Bright's disease, traces of ammonium carbonate are found in the vomited matter. If it be deemed essential that the physician obtain definite data regarding the time consumed in digestion and the presence of the products of fermentation in the stomach, the gastric contents may be removed by a soft-rubber tube in the manner described in the section on Gastrectasia, six or seven hours after the ingestion of food. If undigested remnants of food are obtained, it is safe to assume the existence of impaired digestion, and diminished muscular power on the part of the stomach. By means of the tests given above, approximately accurate data relating to the relative amounts of hydrochloric and of lactic acid may be otained.

Differential Diagnosis.—Ulcer, cancer, dilatation of the stomach, and atonic dyspepsia may be mistaken for chronic gastritis. The differential points between the first three diseases and chronic gastritis will be found in the articles devoted to these subjects. Atonic dyspepsia presents few of the symptoms of irritation and none of the signs of inflammation characteristic of chronic gastritis. In dyspepsia there is hardly any febrile movement. In gastritis this occurs more frequently. In dyspepsia there is less often nausea and vomiting than in gastritis. In dyspepsia there is little thirst, in gastritis often tormenting thirst. In dyspepsia the tongue is often clean, in chronic gastritis almost always coated. In dyspepsia the appetite is generally good, and often ravenous, while anorexia is common in gastritis. In dyspepsia stimulating foods are best tolerated, in gastritis bland ones. In dyspepsia there is less gastric pain, tenderness, and burning than in gastritis. In dyspepsia the urine is generally normal, in chronic gastritis abnormal, containing urates, uric acid, and oxalates. In dyspepsia there is often no loss of weight, while emaciation is the rule in chronic gastritis.

Prognosis.—The duration of chronic gastritis, even when due to causes susceptible of removal, is long, particularly if the disease be wrongly treated or neglected. Relapses are common after apparent cures, and alternate with attacks of more acute gastric inflammation. Chronic gastritis dependent upon incurable diseases of other organs, as of the heart, lungs, or liver, is naturally not amenable to curative measures. Chronic gastritis is not in itself directly fatal, but, if protracted, may induce such a degree of asthenia as to incapacitate the patient for resisting intercurrent acute diseases, and may eventually lead to atonic or obstructive gastrectasia.

Treatment.—The treatment of chronic gastritis resolves itself into (*a*) the prophylactic, and (*b*) the curative treat-

ment. While the former has for its object the prevention of gastritis, the latter aims at fulfilling existing casual and symptomatic indications.

(*a*) Prophylaxis. The aggregate suffering caused by chronic gastritis is enormous, and preventive medicine finds in this disease one of its widest and most fruitful fields. It is the physician's duty to instruct the heads of the families intrusted to his care how to avoid all preventable causes of chronic gastritis, and these are enumerated in the writer's remarks concerning the etiology of this affection. Since recurrent attacks of subacute and acute gastritis strongly predispose to chronic gastritis, these should be carefully avoided. All remediable conditions causing anæmia and malnutrition must be removed, while incurable chronic diseases should receive appropriate palliative treatment. This remark is particularly applicable to diseases causing portal obstruction and consequent venous congestion of the stomach. Nearly all the exciting causes of chronic gastritis are avoidable if the patient only has sufficient moral force to control the cravings of appetite. The physician should, therefore, insist upon moderation in eating and in the use of alcoholic drinks, upon thorough cooking, upon the banishment of the elaborate products of the French *cuisine*, and upon the avoidance of drugs which irritate the stomach or check either its movements or its secretion.

(*b*) Curative Treatment. The indications for the curative treatment are causal and symptomatic. Existing predisposing and exciting causes are, if possible, to be removed, and physiological rest provided for the stomach. Thus, diseases of the heart, lungs, and liver, which lead to secondary gastritis, are to be relieved, and the labor of digestion reduced to a minimum. Even in a mild case it is desirable to adopt simple measures for cleansing the stomach of mucus and of undigested food. This may generally be efficiently accomplished by the use of a large glass of warm or cool water on retiring, and again in the morning, as long as possible before the first meal. The benefit resulting from this measure is referred to the cleansing and quieting effect of the water, which carries away much of the accumulated mucus and any residue of undigested food into the intestine. Sometimes laxative enemata, with water taken as above suggested, suffice to produce efficient alvine evacuations. A seidlitz powder may, however, be given, at first every morning or every second morning, to clear the intestine of undigested food and of accumulated mucus. Should this not prove sufficient, two grains of calomel triturated with milk-sugar may be administered every second evening. Careful and explicit dietetic rules must be framed for each patient in accordance with his personal necessities, for while the principles directing the treatment of all cases are the same, allowance must be made for individual idiosyncrasies and for varying physical conditions. All irritating foods and drinks are to be absolutely forbidden. This rule excludes very hot or very cold articles, alcohol, spices, condiments, and decided acids, which are chemically irritating, and all bulky, rough, or indigestible aliments, which mechanically excite the inflamed mucous membrane. All readily fermentable foods are, at first, to be withheld. In this category must be placed the sugars, starches, and fats, whether alone or in the form of cakes and pastry, where they are found in proverbially fatal combinations. Cooked fats seem particularly indigestible, while small quantities of cream and butter are sometimes well tolerated. Even uncooked fats, however, impede gastric digestion by encasing other foods in a covering more or less impenetrable to the watery gastric juice. The best food for the great majority of cases is milk. Sweet milk may be given undiluted, or diluted with pure water or with Vichy water, the proper proportions of each being determined by experiment. The writer commonly begins with one-fourth Vichy water and three-fourths milk, gradually decreasing the proportion of Vichy water. If sweet milk is not well tolerated, it may be peptonised, or butter-milk may be tentatively employed. Whichever variety of milk is selected ought, in the writer's opinion, to be persistently employed until the subsidence of the graver symptoms betokens relief of the inflammation. The quantity of milk should be about two quarts in the twenty-four hours, and the intervals at which it is taken may vary from two to four hours. Should milk, in any form, be so repulsive to the patient that his repugnance cannot be overcome, Leube-Rosenthal's meat solution may be substituted. In the intervals between the feedings thirst may be allayed by frequent sips of cool water or of carbonated water. When nausea, thirst, and fever have disappeared, more solid foods are gradually to be added to the *menu*. Those most likely to be tolerated are soft-boiled eggs, cold roast mutton, and stale bread well toasted. With these solids small quantities of weak tea or of weak *percolated* coffee, without sugar, may be used as beverages. The quantity of solid food at first employed must be smaller, and the meals more frequent, than in health. The patient should be impressed with the absolute necessity of very slow and thorough mastication. At a more advanced stage of convalescence other meats, such as roasted, broiled, or boiled mutton, tender broiled beefsteak, as well as broiled oysters and tender chicken, may be used. Rare roast beef may, finally, be taken in small quantities, preferably finely scraped and seasoned only with salt. A little rice, well boiled, may next alternate with the toast, and, finally, other vegetables may be tried. The best vegetables are well-boiled rice, baked potatoes, tender carrots, very young pease and tender asparagus. The length of time during which this treatment must be carried out can only be determined by experiment in each case. The least symptom of a relapse, during the use of solid food, should serve as a warning that the milk diet is to be resumed for a season.

Few *drugs* are necessary in the treatment of this disease. Since the gastric juice is deficient in chronic gastritis, it may well be replaced by pepsine and hydrochloric acid. The former may be exhibited in five-grain doses, after each meal. The acid is best administered in doses of from five to ten drops, from one-half to one hour after food. If there be notable acidity of the stomach, as proven by cardialgia and acid eructations, a few grains of sodium bicarbonate may be given before each drink of milk, or before each solid meal. Should the stomach be unusually sensitive to pressure, twenty or thirty grains of the subcarbonate of bismuth may be combined with the soda. If epigastric sensitiveness be extreme, emesis common, or pain severe, small doses of hydrocyanic acid, cocaine, codeia, morphia, or hyoscyamus may be exhibited. In all cases counter-irritation of the epigastrium is good, and, in obstinate cases, even moderate vesication. Constipation is to be relieved by small doses of calomel triturated with sugar, given every second evening, and followed the next morning, if necessary, by a small dose of Hunyadi Janos water, or by a seidlitz powder. The saline laxatives act best on an empty stomach, and their effect is more speedy and complete if they are given warm. Should there be marked gastric tympanites, thirty-grain doses of pure willow charcoal will be found useful as an absorbent of the gases. It is, however, more rational to prevent the fermentations causing gaseous accumulations by decreasing the amount of food and by increasing the pepsin and hydrochloric acid. Antiseptics are rarely necessary, but naphthaline, in five-grain doses, has, in the writer's experience, quickly relieved gastric tympanites not readily controlled by other means. Salicylic acid and the sulphites have been found equally efficient, but more irritating. Intestinal tympanites is commonly easily overcome by salol, in doses of from two and a half to five grains, administered at intervals of from two to four hours. The bad taste in the mouth is greatly diminished by thoroughly cleansing the tongue with a soft rag or brush, and by lotions containing a few drops of the tincture of myrrh, or a few grains of carbolic acid to the ounce. When epigastric tenderness has quite disappeared, a bitter tonic, preferably the tincture of nux vomica, or the infusion of gentian, may be sparingly used to restore tone to the weakened stomach. Anæmia is to be combated by the mildest ferruginous preparations. After complete subsidence of the gastric symptoms, habitual constipation may be relieved by

small doses of aloes and rhubarb in combination, or by a pill composed of aloin, $\frac{1}{6}$ grain ; strychnine, $\frac{1}{100}$ grain ; and extract of belladonna, $\frac{1}{8}$ grain. Great attention should be also paid to general hygiene, all patients being constrained to keep early hours, to lead lives so far as possible free from excitement, and, above all, to exercise moderately in the open air. The clothing should be warm, and the functions of the skin should be maintained by cool sponge-baths. In obstinate cases, washing the stomach is a measure of inestimable value. By this method the stomach is at once relieved of accumulated mucus, undigested aliment, acids and gas. The use of hot or cold water and of cathartics is thus, in a large measure, obviated, and the bowels may be relieved by enemata. The writer's method of employing *lavage* is given in the section on Gastrectasia. Lavage is, at first, best performed every morning, an hour before breakfast. After a short time the washing may be done every second morning, and then, at lengthening intervals, until convalescence is established. In cases requiring the use of the tube, the other therapeutic measures are, in general, identical with those already described as applicable to less severe cases of chronic gastritis. In the most refractory and chronic cases it may be necessary to temporarily resort to rectal alimentation, in the manner recommended under the caption Acute Gastritis. The efficacy of the above treatment, systematically followed, is generally quickly manifest in the relief of symptoms, in the augmentation of weight and in the increase of mental and of bodily energy.

SUPPURATIVE GASTRITIS. *Definition.*—Primary or secondary suppurative inflammation of the stomach, usually affecting the submucous tissues, but sometimes involving other coats of the organ.

Etiology.—The causes of primary suppurative gastritis, which is very rare, are not well known. The disease affects men more often than women, and middle-aged persons rather than the young or the aged. It has been referred to traumatism, gastric ulcer, the abuse of alcohol and to dietetic indiscretions. Silcock reports a case following gastrostomy. In many cases no adequate cause has been ascertained. Secondary, or metastatic, suppurative gastritis, which is more frequent than the primary form, occurs as a complication of acute infectious diseases, especially of puerperal septicæmia and pyæmia.

Morbid Anatomy.—The suppuration may be either circumscribed or diffuse. The former variety is known as abscess of the stomach, which may be single or multiple. It is less rare than diffuse suppurative gastritis. In gastric abscess the pus first collects in the submucous tissues, whence it sometimes makes its way between the muscular layers and into the subserous tissue, or may even perforate the mucous and serous layers, pus being then evacuated into the stomach or into the peritoneal cavity. The abscess is sometimes, however, confined to its original seat in the submucous tissues. If the serous coat is involved, general peritonitis may follow. Exceptionally the abscess cavity may close after the escape of its contents, and cicatrization, occurring, may lead to gastric stenosis. In diffuse suppurative gastritis the pus is also first formed in the tunica submucosa, whence it may invade the intermuscular connective tissue, the subserous structures, the mucous membrane, and the serous coat. In rare instances the inflammatory process is, however, confined to the submucosa. The suppuration commonly involves only a part of the gastric parietes, but it may be coextensive with them, and may even invade the duodenum and the œsophagus. Diffuse and circumscribed purulent gastritis sometimes coexist. The parts of the stomach affected are swollen, and the mucous membrane over the seats of purulent collection is œdematous and spongy, or perforated and ulcerating. The ulcers may be single or multiple. There may be evidences of pre-existing chronic gastritis or of fibroid gastritis. The serous coat frequently becomes inflamed, and general peritonitis may be the result. Thrombi sometimes form in the veins of the stomach, and parts of the thrombi, becoming detached, produce metastatic abscesses of the liver and of the lungs. The microscopical examination of the purulent matter often shows numerous streptococci and other bacteria.

Clinical History.—Primary suppurative gastritis may be acute or chronic. In either case the symptoms are the same, except in their duration. The initial symptom is generally a chill, which may or may not be repeated at irregular intervals. Fever follows, with a rapid compressible pulse and a high temperature, scanty urine, tormenting thirst, headache and anorexia. There is generally much nausea and vomiting, as well as great epigastric pain and tenderness, with meteorism, although these features are not invariably present. The vomited matter sometimes contains pus, but ordinarily only mucus, gastric juice, or bile. Sometimes a tumor, corresponding to an abscess, may be felt in the wall of the stomach. If the abscess ruptures into the stomach, large quantities of pus may be vomited. If perforation occurs into the peritoneal cavity, symptoms of shock appear and are followed by those of acute peritonitis, if the patient survives a sufficient length of time. Jaundice is sometimes present, and there may be either diarrhœa or constipation. Asthenia appears early in the disease and deepens into collapse, death being commonly preceded by delirium and coma. Secondary suppurative gastritis presents essentially the same symptoms, but they are generally completely masked by those of the primary complaint (*vide* article Septicæmia and Pyæmia, in this HANDBOOK).

Callow's case, recited by Leube, presented no symptoms up to the day of its fatal termination, when rupture of the gastric abscess took place, emesis occurred, and speedy collapse followed.

Diagnosis.—The diagnosis can rarely be made during life, although the disease may be strongly suspected when, coincidently with the existence of the above symptoms, a soft gastric tumor is felt, which suddenly disappears simultaneously with the vomiting of a large quantity of pus. Circumscribed suppurative peritonitis might, however, present almost identical symptoms.

Prognosis.—This, although very grave, is not absolutely desperate, as some apparently authentic cases of recovery have been reported. Death usually ensues in about a week, but life may, in cases eventually fatal, be prolonged three weeks or longer.

Treatment.—The treatment is purely symptomatic. Pain and emesis are to be relieved by the hypodermic use of morphine, rest of the stomach secured by rectal alimentation, and the strength sustained by fearless stimulation. Some authors recommend the persistent application of ice to the epigastrium, and the administration of small ice-pellets by mouth. In secondary suppurative gastritis the primary disease naturally claims appropriate treatment.

CHRONIC INTERSTITIAL GASTRITIS AND HYPERTROPHIC PYLORIC STENOSIS. *Definition.*—Thickening of the stomach, either general or limited to the pyloric region, due chiefly to the development of new connective tissue, with which hyperplasia of the muscular coat is usually associated.

Etiology.—Cases of this disease are so rare that few opportunities have been afforded for the discovery of its causes. It affects middle-aged men most frequently, but has been observed in young men, in women, and, very rarely, in children. Chronic interstitial gastritis is often associated with simple chronic gastritis, but there is no proof that it is produced by the latter disease. The abuse of alcohol is regarded as an exciting cause by the majority of authors, but the circumstances under which alcohol leads to this form of gastric inflammation, rather than to chronic gastritis, are not definitely known. Welch observed a case in which there were syphilitic gummata of the liver, and Snellen reported a case in which the disease followed an injury to the epigastrium. Many cases of hypertrophic pyloric stenosis are believed to owe their origin to the cicatrization of a gastric ulcer. Others are without evident cause.

Morbid Anatomy.—The pathological changes may affect the whole stomach equally, or they may be most marked at the pylorus. When the whole stomach is involved, the organ is generally heavier and smaller than

normal. The capacity of the stomach may be reduced to a few ounces, and its size to that of a small pear, which fruit it somewhat resembles in shape. The gastric wall has, in some recorded cases, been more than an inch thick. The dimensions of the stomach may, however, be either normal or abnormally large. Upon section the stomach sometimes does not collapse as in health, owing to the thickness and firmness of its walls, the consistency of which often resembles that of cartilage. The minute examination of the tunics of the stomach shows all the coats of the organ to be structurally altered by that growth of new connective tissue which is characteristic of the disease. The submucous tissues are usually most involved, and the submucosa thus stands out upon cross-section as a broad, firm, whitish layer. The mucous membrane sometimes escapes alteration, but generally the microscope shows the gastric tubules to be compressed, or even obliterated, by hyperplasia of the intertubular connective tissue. In this case, the cellular elements present the same microscopical changes found in simple chronic gastritis (*quod vide*). The muscular layer is often greatly thickened, particularly in its transverse fibres, by hyperplasia of the muscular fibres and of the interfibrillary connective tissue. The subserous and serous coats are similarly thickened, the latter being opaque and of a milky-white color. The entire peritoneum may, rarely, present a similar thickening, or only the visceral layer may be affected. Welch states that adhesions frequently exist between the stomach and surrounding organs. When the above-described interstitial changes involve only the pyloric region, hypertrophic stenosis of the pylorus is said to exist. The result of these localized pathological processes is, as the above name implies, a more or less complete occlusion of the pyloric orifice. Owing to the obstacle opposed to the escape of the gastric contents, the latter accumulate, and, overdistending the stomach, produce gastrectasia, to which is added hypertrophy of the muscular coat.

Clinical History.—The symptoms of chronic interstitial gastritis are variable and ambiguous. In some cases there have been no symptoms, or these have been of so trivial a character that they have been referred to functional dyspepsia. In a case reported by Nothnagel the disease presented the characteristic features of pernicious anæmia. If the disease involves the entire stomach, one somewhat characteristic symptom, at a late stage of the malady, may be inability on the part of the patient to take more than a very limited amount of food or drink without a disagreeable sensation of distention referred to the epigastrium. At this advanced period of the disease the hardened and contracted stomach may be recognized by abdominal palpation, presenting the peculiar form and outline of the normal organ. In such a case the exact capacity of the stomach may be ascertained by first removing all the gastric contents with the soft tube, and then introducing water from a graduated receptacle until a sensation of discomfort is perceived. Before the development of the symptoms mentioned there may be those of a protracted chronic gastritis—vomiting, emaciation, and asthenia being particularly prominent clinical features, while pain is almost or quite absent. Sometimes there is, however, violent gastralgia. In that form of chronic interstitial gastritis known as hypertrophic stenosis of the pylorus, the clinical history corresponds to that of obstructive gastric dilatation, to which the reader is referred. The symptoms of dilatation are sometimes preceded by those of chronic gastritis. The hypertrophic pylorus can occasionally be made out by abdominal palpation, and is apt to be mistaken for a carcinomatous tumor.

Differential Diagnosis.—Diffuse chronic interstitial gastritis is to be distinguished from simple chronic gastritis. The distinction can only be made with an approach to certainty when, in the later stages of the disease, a contracted and hardened tumor, presenting the contours of the stomach, can be mapped out.

Hypertrophic stenosis of the pylorus may be mistaken for atonic dilatation of the stomach and for cancer. The differential points between hypertrophic stenosis of the pylorus and atonic dilatation are stated in the section on Gastrectasia. Cancer can, generally, be excluded by attention to the following points: Patients with carcinoma have almost always passed middle life, while stenosis of the pylorus may affect the young. In cancer there is often a family history pointing to that disease. In hypertrophic stenosis this is not true. In cancer the duration of the disease is short, usually under two years; in hypertrophic stenosis it may be long. In cancer there is commonly much pain; in stenosis there is generally little or none. In cancer hæmatemesis is common, but it is rare in simple stenosis. In cancer there is a peculiar cachexia, which is absent in hypertrophic stenosis. In cancer there may be secondary hepatic carcinomata, while metastasis does not, of course, occur in stenosis. In cancer the tumor is tender on pressure, while in hypertrophic stenosis it is not so.

The *prognosis* of chronic interstitial gastritis, of either form, is serious, the patients ordinarily succumbing to inanition and asthenia.

The *treatment* of chronic interstitial gastritis, when diffuse, embraces the exclusion of all irritating ingesta, the use of bland, and, if necessary, of predigested foods, given in small quantities and at frequent intervals, and the employment of rectal alimentation. In cases of hypertrophic stenosis of the pylorus the treatment is the same as that recommended in the following section on Gastrectasia.

Dilatation of the Stomach (Gastrectasia). *Definition.*—That condition of the stomach in which the organ is both abnormally capacious and inadequate to the performance of its functions, *i.e.*, the digestion and absorption of some foods and the propulsion of other alimentary materials into the intestine. Two forms of gastrectasia are recognized, namely, hypertrophic dilatation, in which the gastrectasia is preceded or accompanied by muscular hypertrophy, and atonic dilatation, in which no compensating hypertrophy occurs.

Etiology.—The classification of the causes producing gastrectasia, suggested by Professor William H. Welch (Pepper's "System of Medicine," vol. ii., p. 591, edition 1885), is so clear and comprehensive that the writer introduces it in this place. The three causative conditions recognized in Professor Welch's classification are: I., Stenosis of the pylorus and of the duodenum; II., abnormalities in the contents of the stomach; and III., impairment of the muscular force of the stomach. These general causative conditions may be again subdivided into the following tabulated classes. It will be noticed that causes belonging to Class I. occasion dilatation with hypertrophy, while those of Classes II. and III. lead to atonic dilatation.

I. Stenosis of the Pylorus or of the Duodenum. 1, Cancerous; 2, cicatricial; 3, hypertrophic (of pylorus); 4, from external pressure; 5, congenital (of pylorus) (?); 6, from torsion of duodenum.

II. Abnormalities in the Contents of the Stomach. 1. Ingesta: (*a*) Excessive; (*b*) imperfectly masticated; (*c*) indigestible. 2. Stagnation and fermentation in consequence of chemical insufficiency of the stomach, as in chronic catarrhal gastritis and functional dyspepsia.

III. Impairment of the Muscular Force of the Stomach. 1. Organic changes in muscular coat: (*a*) Partial destruction by ulcers and cancers; (*b*) inflammation, as in chronic catarrhal gastritis and peritonitis; (*c*) degenerations (fatty, colloid, amyloid); (*d*) œdema (?); (*e*) cirrhosis of stomach. 2. Mechanical restraint: (*a*) By adhesions; (*b*) by weight of herniæ. 3. Impaired nutrition and general muscular weakness, adynamic dilatation from typhoid fever, tuberculosis, anæmia, etc. 4. Paresis from neuropathic causes (?).

Obstruction at the pylorus, or near that orifice, in the duodenum, is the most important cause of gastrectasia, which is, generally, of the hypertrophic variety, *i.e.*, accompanied by hypertrophy of the gastric muscles. Hypertrophy of these muscles may, however, sometimes quite compensate the obstructive lesion, in which case gastrectasia does not ensue. In almost all cases of hypertrophic gastrectasia the order of events is as follows:

First, obstruction, then compensatory hypertrophy without dilatation, and, finally, hypertrophic dilatation in which the dilatation eventually preponderates.

I. Stenosis of the Pylorus or of the Duodenum. Pyloric stenosis is more frequently due to cancer than to any other morbid condition, and the next most frequent cause is contraction of cicatrices resulting from pyloric gastric ulcers. Duodenal stenosis, leading to dilatation of the stomach, may also be brought about by cicatrices and tumors of that part of the intestine or by external pressure. Under the caption Chronic Interstitial Gastritis it has been stated that this disease, when limited to the region of the pylorus, may cause obstruction of that orifice, and stenosis may, very rarely, be caused by sarcomata, myomata, fibromata and other benign tumors. The most common causes of stenosis from external pressure are tumors, such as hepatic carcinomata, and contracting cicatricial bands resulting from circumscribed peritoneal inflammation. The question of the existence of congenital pyloric stenosis is still *sub judice.* Landerer reported ten cases of supposed congenital stenosis of the pylorus, but his conclusions regarding their congenital character have not been generally accepted. Torsion of the pylorus or of the duodenum, or traction upon these parts by complete inguinal hernias, particularly by those containing the transverse colon or the omentum, may lead to stenosis of the intestine, and to secondary gastrectasia.

II. Abnormalities in the Contents of the Stomach. These abnormalities relate either to the character of the gastric contents or to unnatural fermentations in the food. Ingesta may be abnormal in quantity, in quality, or in their preparation. Vegetable foods, if relied upon to the exclusion of animal diet, may induce dilatation because of the large volume of aliment required, and liquids, as ice-water or beer, may act in the same way, when ingested in considerable quantities. Foods which are difficult of digestion, either because not easily penetrated by the gastric juice or because readily fermentable, may cause atonic dilatation ; and the same is true of raw and of imperfectly cooked aliments, and of those not thoroughly masticated and insalivated. It is possible that the long continued abuse of drugs which diminish the secretions of the stomach, or which inhibit its peristole, may also contribute to the development of atonic gastrectasia. Atonic dilatation is, moreover, often brought about by repeated attacks of indigestion and of gastritis, which favor the retention and decomposition of the contents of the stomach. In these cases both the secretion and the peristaltic movements are inhibited, and abnormal fermentation is the inevitable result. Fermentation leads to the evolution of gases which distend the stomach, and of acids—chiefly acetic, butyric, lactic and hydrosulphuric acids—which by their irritating character aggravate the pre-existing inflammation.

III. Impairment of the Muscular Force of the Stomach. Diminution in the muscular power of the stomach may be due to the various organic lesions of the gastric parietes enumerated in the above table. The weakening effect of chronic gastritis and of peritonitis has been already alluded to. Ulceration, whether simple or carcinomatous, and of varying depth, may diminish the stomach's contractile power, as well as amyloid, colloid and fatty degeneration of the gastric muscles, and the changes incident to chronic interstitial gastritis. Among the remaining tabulated causes of atonic dilatation should be emphasized the general weakness and atony of all the bodily tissues, resulting from anæmia, acute febrile diseases and chronic wasting affections. Fenwick refers to a case, reported by Willis, in which primary paralysis of the stomach followed an injury to the splanchnic nerve. It is often quite impossible to assign a single definite cause for the occurrence of dilatation in an individual case, as several etiological agents are almost certain to co-operate in its production. This is particularly true of gastritis, muscular insufficiency, and fermentation, which most frequently go hand in hand, and which are, to a large extent, interdependent. Diabetic patients suffer from gastrectasia on account of the polyphagia characteristic of their primary disease, and a sedentary life, combined with a generous diet, has the same result. Hypertrophic dilatation of the stomach is most frequent after middle life, because cancer, the chief cause of this variety of gastrectasia, develops at that age. Atonic dilatation is most common in middle life, but may occur at any age. When occurring in childhood it particularly affects rachitic children.

Morbid Anatomy.—While the *post-mortem* recognition of largely dilated stomachs presents hardly any difficulty, that of slightly and of moderately dilated stomachs may be impossible, because of the wide limits within which the size of the normal organ varies. If a reliable history can be obtained, the clinical test of gastrectasia, viz., inability of the stomach to empty itself, may be utilized in making a *post-mortem* diagnosis. Even when the stomach reaches below the umbilicus, it is not necessarily dilated. Perfectly normal stomachs, which are of a looped shape, or which occupy a vertical position such as exists in fœtal life, may extend considerably below the navel. A. Flint, Sr., states that tight-lacing may depress the stomach to a notable extent. The size of a dilated stomach may, on the one hand, be so small that the clinical test of insufficiency is necessary to render the diagnosis at all certain, or, on the other hand, may be such that the stomach contains gallons of liquid, occupies nearly the whole abdomen, and reaches nearly or quite to the iliac bone. Cases have been reported in which the dilated organ descended even into the true pelvis, or into the sac of a complete inguinal hernia. Stomachs which are the seat of hypertrophic dilatation from obstruction are generally of larger dimensions than those affected by atonic dilatation. The fundus becomes first dilated, and although the entire organ may subsequently be involved, the fundus remains more largely dilated than the cardiac and the pyloric extremities. The increased weight of the dilated stomach generally causes it to be displaced downward, the pylorus occupying a lower plane than normal and dragging the duodenum downward from its natural position. The stomach thus sometimes comes to assume a more vertical position than that of health. If, however, the pylorus be fixed, as in cancer, the long axis of the organ is more nearly transverse than normal, owing to the predominant dilatation of the fundus. In the early stages of gastrectasia from obstruction, the walls of the stomach are generally notably thickened, especially at the pylorus, by hyperplasia of the muscular coat. At a later period of the disease the gastric parietes may be found normal in thickness, or even decidedly thinned In non-obstructive gastrectasia the muscular coat may be hypertrophied, but it is commonly atrophied. In both varieties of gastrectasia fatty degeneration of the muscular fibres, and a pathological condition described by Maier as colloid degeneration of these fibres, is not very rare. The mucous and other coats of the stomach ordinarily present in dilatation the changes already described as characteristic of chronic gastritis. In addition to the morbid anatomical changes peculiar to dilatation, those of the primary disease, which has occasioned gastrectasia, will be observed. These primary pathological conditions are enumerated in the preceding etiological table. If the gastrectasia be caused by duodenal obstruction, this part of the bowel will be likewise dilated. The œsophagus is often dilated in pronounced cases of gastrectasia. The liver, spleen, intestine, diaphragm and heart are sometimes displaced by the enlarged stomach. The spleen, liver and pancreas are frequently atrophied. Many writers refer these atrophic changes to the pressure of the stomach, but they are, more probably, merely subordinate features of the general emaciation resulting from gastrectasia. The pressure of indigestible foreign bodies, such as coins or bits of wood, is said by Leube, when long continued, to have occasionally produced circumscribed or sacculated dilatation of the stomach. .

Clinical History.—The symptoms presented by patients suffering from gastrectasia are referable partly to the original causative conditions of the disease, and, partly, to the dilatation proper. The symptoms due to the causes which eventually produce gastrectasia, may exist for a long time before the supervention of those denoting dila-

tation, and, if properly interpreted, may thus afford an indication for the adoption of preventive treatment. The symptoms, which are to a certain extent premonitory, as well as concomitant, are usually those of carcinoma or of ulcer in cases of hypertrophic gastrectasia, and of chronic gastritis in the early stages of atonic dilatation. These symptoms need not be enumerated in this place, as they are given in this article under their respective headings. Among the symptoms properly referred to dilatation, but which do not occur in hypertrophic gastrectasia so long as compensation is complete, the most prominent is copious vomiting at irregular intervals. This symptom is almost constant in dilatation from obstruction of the pylorus or of the duodenum, and is also frequent in the earlier stages of atonic gastrectasia. When, in either class of cases, the gastric nerves and muscles have partly sacrificed their functional powers, owing to compression, atrophy, or degeneration, emesis becomes less frequent and may entirely cease. The most characteristic features of this vomiting are its copiousness and its tendency to a more or less periodical recurrence. The volume of vomited matter often far transcends the normal capacity of the stomach, sometimes amounting to several quarts. The length of time intervening between successive acts of emesis varies with the irritability of the stomach and with the amount ingested. Two, or even more days, however, generally intervene between the paroxysms of vomiting, but the interval may be of only a few hours' duration. The emesis commonly occurs several hours after meals, and is frequently explosive, being unaccompanied by notable straining. The vomiting does not completely empty the stomach, which is often found still largely distended after the emesis has ceased. The vomited matters consist largely of undigested food, which fact may be ascertained by macroscopical inspection. In some instances portions of aliment taken days before their rejection may be recognized. Their odor is that of putrefaction. Their reaction is acid, from the presence of lactic, acetic, and butyric acids, or, rarely, from that of gastric juice. Their color varies with their composition. When the diet has been a mixed one, the color is generally yellowish, or brownish-red. Sometimes it is almost black or gray, with interspersed clumps of a blackish color. The upper layers of the vomited matters are often white and frothy. Strings and shreds, apparently of muco-pus, are dependent from this layer, reaching for some distance below the surface. At the bottom of the vessel are seen irregular masses of solid material.

Microscopically examined, the vomited matter is found to contain food particles, either undigested or but partly digested, bacilli and other bacteria, sarcinæ ventriculi, torulæ cerevisiæ, and other fungi or their spores, crystals of fatty acids, flat epithelium from the stomach and œsophagus, mucus, pus, and occasionally blood-corpuscles. Sometimes hæmatin is detected by chemical tests, when no blood-corpuscles can be recognized, and bile may be present in sufficient quantity to furnish its characteristic chemical reactions. Blood is more frequently found in cases of gastrectasia from cancer than in simple atonic dilatation, while bile is more often present in atonic gastrectasia. Various gases are held in solution in the vomited matters. Chief among these gases are oxygen and nitrogen, in about the same proportions as in the atmosphere; sulphuretted hydrogen, hydrogen and carbonic dioxide. In a case observed at Frerich's clinic, olefiant gas and some undetermined gaseous hydrocarbons were present. In this case the gases burned with a yellow flame. In other, comparatively rare, instances, the gas burns with a whitish flame. The gases in question mostly result from the abnormal fermentations in the stomach, but the nitrogen and oxygen may be swallowed with the food. Acetic, butyric, lactic and hydrochloric acids are at times present. These, with the exception of the last, result from fermentative processes. The clinical test of gastrectasia consists in the habitual discovery, among matters rejected from the stomach by vomiting, or withdrawn by the stomach-tube, of food taken on the preceding day, or even earlier. Subacute or chronic gastritis may cause the retention of food for an equal length of time; but, if this test be habitually successful, the existence of gastrectasia may be confidently assumed. The error is sometimes committed of considering stomachs of unusually large size, as shown by physical examination, to be dilated. The weight of authority is, however, in favor of regarding only those stomachs as dilated which, independently of their capacity, are inadequate to the performance of their digestive and propulsive functions.

Physical Signs.—Inspection of the abdomen sometimes reveals unusual prominence of the epigastric, of the left hypochondriac, and sometimes of other abdominal regions. If the abdominal walls are thin and relaxed, the outlines of the dilated stomach may be distinguished and the peristaltic gastric movements studied. This peristole may occur spontaneously, or may require to be excited by percussion and pressure. The movements begin at the cardiac extremity of the organ and slowly pass toward the pylorus. Rarely they alternately progress in either direction. These peristaltic movements are commonly indicative of hypertrophic dilatation, but that they are not characteristic of gastrectasia alone is shown by their occasional occurrence in healthy stomachs. Kussmaul refers such visible movements, occurring independently of gastrectasia, to a neurosis of the stomach. Similar vermiform movements in the intestine may simulate those of the stomach. If, while the abdominal protuberance is under observation, about thirty grains of sodium bicarbonate and fifteen grains of tartaric acid, in separate solutions, be drunk in quick succession, as recommended by Frerichs, sufficient carbonic dioxide may be generated to more fully distend the stomach, and thus to render its outline more clearly apparent. In widely dilated stomachs a much larger quantity of these reagents may be necessary to efficiently distend the stomach. This method of distending the organ is not uniformly successful, inasmuch as the gas may sometimes escape into the intestine, through a relaxed pylorus, almost as rapidly as it is generated. The method has, besides, the disadvantage of occasionally distending the stomach to such an extent as to cause severe pain. In such an emergency the prompt introduction of the stomach-tube is indicated, and quickly affords relief. Some authors advocate the employment of distention with gas, when the stomach is empty, to demonstrate the extent of the dilatation, but the method is open to so many objections that its usefulness is problematical. Even a healthy stomach may be distended to a misleading extent through the rapid generation of gas by the method in question, and in an organ the walls of which are relaxed by disease, the results would be still less reliable. Were the supposed gastrectasia due to malignant disease, the friability of the gastric walls might be such that rupture would occur from overdistention with the gas.

Palpation may sometimes enable the examiner to outline the borders of a dilated stomach, to obtain fluctuation and to perceive the peristaltic gastric movements. If the stomach be not overdistended with liquid, palpation may also elicit a splashing sound in the organ, which is, however, generally more readily produced by gentle succussion of the entire abdomen. If succussion be resorted to, the patient is requested to lie upon his back and to relax his abdominal muscles. The physician then grasps the iliac bone and the lumbar region with either hand, the thumbs being directed forward, and imparts a quick, lateral, vibratory motion to the body, simultaneously applying his ear to the epigastrium. This succussion sound is only diagnostic of gastrectasia when obtained six or eight hours after a meal, or from three to four hours after the ingestion of liquids, as it is often heard, under other circumstances, in perfectly healthy stomachs. Some persons can produce it at will, by rapid movements of the diaphragm, by holding the breath and quickly contracting the abdominal muscles, or by simply changing their position. The gastric succussion sound may be almost perfectly simulated by a like splashing sound in the transverse colon. An accessory diagnostic measure, suggested by Leube, consists in feeling, through the abdominal

wall, the end of a hard stomach-tube introduced into the stomach. If the tube be felt far below the umbilicus, dilatation is, according to Leube, probably present. This method is, however, not to be recommended, since the hard tube may inflict injury upon the gastric wall, and, even when introduced, cannot always be recognized with certainty. Oser objects to Leube's method because the sound may slip along the greater curvature, and, bending upward, may even reach the pylorus, so that its point will be felt far above the most dependent part of the stomach. Palpation may show upward displacement of the heart, and cardiac arhythmia if the stomach is greatly distended with gas.

Auscultation, besides aiding in the detection of the gastric succussion sound, may reveal the presence, in the stomach, of fine crackling or hissing sounds, produced by the bursting of minute bubbles of gas upon the surface of the liquid contents of the stomach. This gas, as already explained, owes its origin to abnormal fermentations.

Percussion often affords great assistance in mapping out a dilated stomach, but, in other cases, the information it conveys is negative or misleading, from the fact that intestinal tympanites may displace the greater curvature upward or may overlap the stomach to a variable extent. Over a stomach which is considerably dilated, and contains liquid and gas, there is, when the patient is erect, a tympanitic percussion note above the level of the liquid. The line of flatness is changed, when the patient assumes the dorsal or the lateral decubitus, to that part of the viscus which is the most dependent, while the tympanitic resonance is heard over the highest point of the stomach. The most rational method of ascertaining the existence and the extent of dilatation is, in the writer's opinion, that referred by Welch to Penzoldt. This method consists in withdrawing all fluids from the stomach by the tube, whereupon the pre-existing flatness disappears. If, now, a moderate quantity of liquid, from a pint to a quart, be introduced through the tube, flatness will reappear. If the flatness extends below the umbilicus, dilatation exists, and the extent of the gastrectasia may be approximately ascertained by noting the lowest level reached by the liquid.

General Symptoms.—The bowels of patients suffering from gastrectasia are generally obstinately constipated, because a comparatively small amount of aliment gains access to the intestine within a given time, and the fæcal matter is soon deprived of its fluid constituents by the intestinal absorbents. The bile and the intestinal juice are also reduced to a minimum, and intestinal peristole is consequently retarded. Sometimes diarrhœa alternates with constipation, and is best explained by the assumption that occasional relaxation of the pylorus allows the entrance of a large volume of undigested and fermenting matter into the bowel. The tongue may be either coated or clean. A coating speaks for the existence of gastritis. The urine is usually acid, scanty, high colored, and of high specific gravity, either from retention of liquids in the stomach or as a result of coincident gastritis. The urinary sediment is often abundant, and contains, chiefly, amorphous urates and oxalate of lime. In gastrectasia uncomplicated by gastritis, the specific gravity may be low and the reaction neutral or alkaline. In this case, amorphous phosphates and crystalline phosphates of lime and magnesia may be precipitated. Quantitative analysis has revealed a relatively small quantity of urea and a large amount of phosphates in many of the writer's cases. The pulse is apt to be slow and feeble, the surface cool and dry, or clammy, and the temperature normal. Owing to the lowered vitality, the temperature may be subnormal during the early morning hours. Intercurrent attacks of subacute or of acute gastritis may reverse these conditions, and the pulse may sometimes become irregular, fluttering, frequent, and intermittent from disturbed cardiac action due to the pressure upon the thoracic viscera of a stomach distended with gas. Gastric tympanites may also induce temporary dyspnœa. Patients are more or less emaciated, in proportion to the extent of their gastrectasia and to the nature of its cause. They are ordinarily anæmic, nervous, hypochondriacal, sleepless, and sometimes apathetic. They suffer from headache and nausea, perhaps referable to auto-infection with toxic ptomaïnes, and sometimes persisting for a number of days. The appetite is generally diminished, and often lost. If, however, there be no gastritis, the appetite may be good and even ravenous, because of the small amount of nourishment assimilated. There is often constant and tormenting thirst, only aggravated by the ingestion of liquids, because they augment the gastric dilatation and still further retard absorption. There is, ordinarily, a sensation of gastric oppression and distention, at least until the dilatation has progressed so far as to paralyze the gastric sensory nerves. This oppression is temporarily relieved by emesis. During the earlier stages of dilatation there is often acute gastralgia, probably due to advancing distention, and generally occurring after meals. This pain may be entirely relieved by the prompt and efficient use of the stomach-tube. Pyrosis and the eructation of badly smelling and tasting gases and liquids are frequent symptoms. True epileptic convulsions and tetanic spasms may occur in the latest stages of gastrectasia, as was first stated by Kussmaul. This author holds that they are due to abnormal dryness of the tissues from continuous abstraction of fluids, and are, hence, analogous to the convulsions in the asphyxia of cholera. Kussmaul supports this view by the fact that the spasms generally occur after emesis, or lavage of the stomach. It is, however, possible that the convulsions are due to cerebral and spinal anæmia, to toxæmia from the absorption of ptomaïnes, or to imperfect elimination of urea. The tetanic spasms involve by preference the abdominal muscles, the flexors of the hands and forearms, and the calves of the legs, but sometimes affect the muscles of the neck and face. The pupils are sometimes contracted, and nystagmus has been observed. Consciousness is commonly retained, but occasionally it is lost. Coma may follow the spasms or be developed independently of them. The convulsions may be momentary, or they may continue for hours or days. They are followed by great asthenia and by tenderness over the affected muscles. The spasms are not, in themselves, fatal.

Diagnosis.—Chronic gastritis may be mistaken for slight grades of gastrectasia, but may be differentiated by the application of the clinical test for dilatation already alluded to, *i.e.*, by ascertaining, with the syphon, whether the stomach habitually contains remnants of food in the morning, when the patient rises. If food be thus found, dilatation exists. *Ascites* may be mistaken for gastrectasia, but not if moderate caution be observed. In *hydroperitoneum*, flatness exists in the lowest abdominal regions when the patient is erect; the reverse obtains in gastrectasia. In simple hydroperitoneum there is no succussion sound. In hydroperitoneum the withdrawal of fluid from the stomach, by means of the tube, does not affect the size of the abdomen nor the area of dulness. *Hydatids of the liver*, ovarian tumors, distention of the urinary bladder, and pregnancy are said to have been mistaken for gastrectasia, but such errors need never occur, even to tyros in physical diagnosis.

Prognosis.—The best prognosis is afforded by cases of atonic dilatation without pyloric or duodenal obstruction. In these cases, if the dilatation be moderate in degree, a cure may be reasonably expected from proper treatment persistently pursued. In cases of marked atonic gastrectasia a complete cure is only rarely effected, and it must be admitted that the treatment is usually only palliative. Still, even in these cases, marked relief is often obtained, the patients gaining in weight and strength sufficiently to pursue their ordinary avocations for an indefinite period. A larger proportion of recoveries would, doubtless, be reported were it not for the fact that patients, encouraged by their notable improvement, and presuming too much upon their powers of digestion, frequently assign to the stomach tasks far beyond its capacity to perform, and wilfully violate fundamental dietetic laws. The prognosis, in dilatation secondary to obstructions which are not cancerous, is less favorable than that of

atonic gastrectasia, although life may be considerably prolonged and suffering be much relieved by proper therapeutic measures. In a few cases of cicatricial stenosis following ulcer, resection of the pylorus has permanently cured when all other means were unavailing. In dilatation from carcinomatous obstruction, the prognosis is hopeless. Gastrectasia, when fatal, usually causes death from inanition, very rarely by rupture of the stomach.

Treatment.—The treatment of gastrectasia embraces prophylactic and curative measures. The former are, in general, deplorably neglected, perhaps because the causes of dilatation are not fully understood. Prophylaxis is naturally powerless to avert certain obstructive lesions, such as carcinoma, but the timely and persistent treatment of subacute and chronic gastritis, as well as of asthenia and anæmia from various removable causes, might often avert atonic dilatation. It is the imperative duty of the physician to carefully follow cases of gastritis until the danger of gastrectasia is averted. Parents and guardians of the young should be made to understand the far-reaching and disastrous effects of overfeeding, and of disregarding so-called dyspeptic ailments of apparently trivial import. Young persons should be repeatedly warned against improper foods, immoderate indulgence and insufficient mastication. The curative treatment should aim to fulfil three indications: First, to empty and cleanse the stomach, and to prevent the recurrence of overdistention; second, to relieve coexistent gastritis; third, to improve the general condition of the patient. The objects accomplished by meeting these indications are the following: Thorough evacuation and cleansing of the stomach relieves tension of the gastric walls, placing them in a more favorable condition for regaining their normal resiliency and contractility. The peristole of the stomach is thus, in favorable cases, measurably strengthened, the secretion of the gastric juice restored, absorption facilitated and stagnation prevented. The removal of tenacious mucus and of irritating fermenting matters diminishes the dangers of auto-infection from ptomaïnes, checks morbid fermentations and subdues gastritis. The curative efficacy of these measures is most plainly manifest in moderate atonic dilatation, but even in incurable obstructive gastrectasia they are of inestimable value in palliating distressing symptoms. The relief of gastritis controls the hypersecretion of mucus, and aids the re-establishment of the normal gastric secretion, while improvement of the patient's general condition can but react favorably upon the local morbid conditions. In cases of moderate dilatation, particularly if the patients be women or children, heroic measures for the evacuation of the contents of the stomach are unnecessary. Mild cathartics, preferably hot salines, as Karlsbad salts, Hunyadi Janos, or citrate of magnesia, employed every second day, two hours before the morning meal, will usually suffice. In cases of marked gastrectasia, and in any instance where a speedy result of treatment is the first consideration, recourse should be had to the siphon-tube or to the stomach-pump. The medical world is indebted to Kussmaul for first advocating, in 1867, the systematic employment of these efficient means of emptying and cleansing the stomach. The instruments necessary for the mechanical cleansing of the stomach are, respectively, the ordinary stomach-pump, with its stiff gum-elastic tube, and a soft elastic stomach-tube, or catheter, to which a funnel is adapted, and which acts upon the principle of the siphon. The tubes generally employed in this country are made of perfectly elastic, reddish-brown rubber. Their diameter varies from one-fourth to one-half an inch, and their length from twenty-four to thirty inches. The writer prefers a tube about one-third of an inch in diameter. The so-called Faucher tube, much used in Europe, is six feet long, and the funnel is directly attached to its proximal extremity. The tube should always be new and strong, lest a portion be torn away and retained in the stomach, and it should be provided with two sunken, so-called velvet eyes, in order that the friction may be reduced to a minimum, and that one eye may remain pervious if its fellow becomes obstructed. The catheter proper is generally connected, by means of a small piece of stout glass tubing, with a piece of elastic tubing of about the same calibre as the catheter, which, when the tube is introduced into the stomach, constitutes the long arm of the siphon. The elastic tubing should be long enough to nearly reach the floor when the patient is seated. The use of the stomach-pump is so generally understood that any explanation is unnecessary. The pump should, in the writer's opinion, never be used when the soft tube will accomplish the object proposed, for the reason that its rigid tube is more disagreeable to the patient, and far more irritating to the œsophagus and the stomach than the elastic catheter. There is, moreover, danger that aspiration may be performed with such violence, by means of the pump, as to separate portions of the gastric mucous membrane. This accident has frequently occurred, and, although not serious, is still to be deprecated. In some instances better results are attained by the pump than by the soft tube. This is particularly true when a stomach containing large pieces of alimentary matter is to be cleansed. In such a case the eyes of the soft tube often become occluded by solid masses of food, and the aspirating power of the siphon is inadequate to their removal. The method of employing the siphon-tube is as follows: The patient should assume the sitting posture, throwing his head backward and holding his mouth open. The tube, having been lubricated with vaseline or oil, is introduced into the pharynx, and the patient is instructed to make repeated movements of deglutition. The physician may hasten the progress of the tube and prevent its rejection by making moderate pressure upon the proximal extremity. The tube, having been introduced to the depth of about twenty-six inches, is intrusted to an assistant, or to the patient himself, care being taken that it be held immovably in one position. This precaution is necessary, as movements of the tube often induce nausea and excite reversed œsophageal peristaltic movements. The funnel is now attached to the elastic tubing, filled with the liquid selected for irrigation, from a graduated glass, and elevated a short distance above the patient's head, as shown in Fig. 3733. In proportion as the liquid escapes from the funnel it is replenished, until about a pint has been allowed to flow into the stomach. Then, before all the liquid has escaped from the funnel, the latter is lowered to a point some feet below the stomach, as shown in Fig. 3734, and the contents of that organ evacuated by the action of the siphon. The elastic tube, to which the funnel is attached, should be longer than it is represented in the cut. It will be observed that the tube here shown is the long, continuous Faucher tube, often employed in Europe, but little used in the United States. When the current ceases to flow from the stomach, more liquid is introduced, and the process is continued until the liquid returns as clear as when

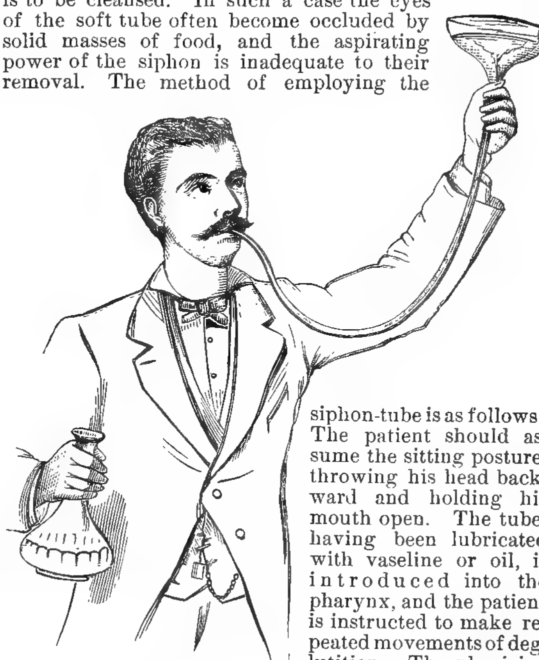

FIG. 3733.

it enters. The tube is then gently withdrawn, its upper end being compressed between the fingers to prevent the escape of the contained liquid. The liquid best adapted to the majority of cases is lukewarm water. Various medicaments may be added to the water to meet existing indications. If there be much acidity of the stomach from morbid processes of fermentation, one-half drachm of sodium bicarbonate may be added to each pint of water used. It is held by many that adhesive mucus is more easily detached by such an alkaline solution. If active fermentation is taking place in the stomach, antiseptics may be employed, the best being carbolic acid, salicylic acid and resorcin, in one per cent. solutions, these solutions being followed by a few measures of pure water. In cases characterized by great gastric irritability the writer has employed water at a temperature of about 102° F., with much success. The hot water appears to exert a decided sedative action upon the gastric mucous membrane, and to cleanse its surface more quickly and thoroughly than cool or lukewarm liquids. Certain difficulties may attend the simple operation of lavage. One of these relates to the introduction of the tube. This may be rendered very difficult by pharyngeal or œsophageal spasm. A certain amount of pharyngeal spasm generally occurs at the first introduction. This may often be obviated by spraying the throat, for a few minutes, with a two per cent. solution of hydrochlorate of cocaine. Should the spasm prove protracted, the operation may be postponed, or a tube sufficiently stiff to resist the muscular pressure may be introduced. After a few introductions this is usually unnecessary. Some patients complain of a sensation of oppression and of dyspnœa when the tube is in position. This discomfort is relieved by repeated deep inspirations, the air being allowed to enter through both mouth and nose. The current of liquid may be interrupted by various conditions. One of these is occlusion of the eyes of the catheter by food or mucus. The obstacle may sometimes be removed by voluntary straining efforts made by the patient, the breath being held and the abdominal muscles called into action, or by forced coughing. The obstruction may be temporarily removed by allowing more water to pass through the tube into the stomach, and the offending object will then occasionally present its shorter diameter to the eye and be expelled. Should all efforts at removing the obstruction fail, the tube may be removed, cleaned, and reintroduced, or, in the event of recurrent occlusion, the stomach-pump may be used. The current occasionally ceases because the tube has not been introduced to a sufficient depth and its eyes are above the level of the liquid contents of the stomach. On the other hand, the pliable tube, if introduced too deeply, may impinge upon the greater curvature of the stomach, or, passing into the pyloric region, may bend upon itself, thus checking the current. These difficulties are respectively obviated by withdrawing the tube or by introducing it to a greater depth. Paroxysms of coughing interrupt the current, the continuity of which is re-established by the introduction of more liquid. The liquid introduced should always be measured and compared with the amount withdrawn, in order that no accumulation shall take place. Cases have been reported by Jackson and Leube, in which the entire tube was swallowed and subsequently rejected by vomiting. This accident may be prevented by attaching a string to the upper extremity of the tube before its introduction. The leading contraindications to the use of the tube are aneurism of the aorta, recent gastrorrhagia, most cases of gastric ulcer, cancer of the œsophagus or of the cardiac orifice and marked asthenia. The passage of the tube sometimes produces such violent vomiting and œsophageal spasm as to cause syncope, in which case the simpler methods of cleansing the stomach must be relied on. Authorities do not agree regarding the best time of day for the operation of lavage. The majority are, however, in favor of performing the operation before breakfast. The writer prefers this time, because the stomach has then had the fullest possible opportunity for the digestion and absorption of food. Less chyme is thus lost than when lavage is done later in the day. Again, the food, having been reduced to a pultaceous mass, does not obstruct the tube, and the operation is thus accomplished with greater certainty and despatch. The stomach should be washed every day at the beginning of the treatment. Later, if progress be satisfactory, it may be washed every second or third day. The frequency of the operation is, however, to be entirely governed by the symptoms in each case. The use of the soft tube may be safely left to the patient, after a few lessons. The use of the tube should not be continued after the stomach is restored to health, and patients should be cautioned not to allow the consciousness that relief from suffering can be quickly obtained by a resort to the tube to betray them into dietetic indiscretions.

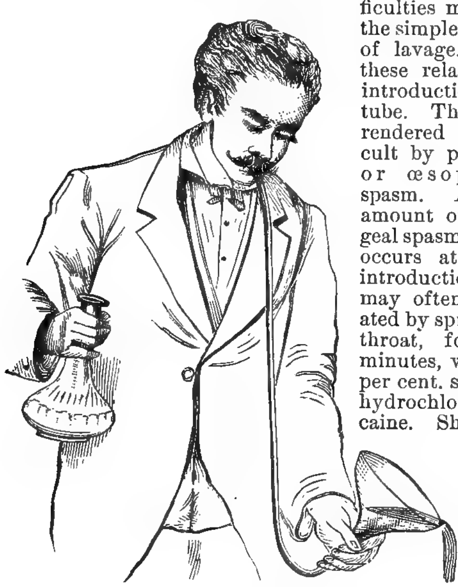

FIG. 3734.

The dietetic treatment of gastrectasia is even more important than the mechanical. The objects to be accomplished by regulation of the diet are the prevention of fermentation, of overdistention and of irritation. The foods selected should, therefore, be mostly solid, small in volume, unstimulating, not easily fermentable and not hot. They should be taken at intervals of two or three hours, in small quantities. Liquids should be taken sparingly, thirst being relieved by small swallows of water, rather than by large volumes taken at one time. Nitrogenous foods are, in general, preferable to the carbo-hydrates and fats, because the former are small in bulk, and since the latter, not being acted on by the gastric juice, tend to more rapid decomposition and fermentation. According to this principle, fresh mutton and beef, eggs, oysters and tender chicken are ordinarily best tolerated, tender cold mutton usually proving the most digestible of all these foods. Toasted bread, with a little fresh butter, may soon be added to the *menu*, and weak tea, or weak *percolated* coffee, without sugar, may be sparingly used with the meals. If the case progresses favorably, other vegetable foods may be tentatively added to the bill of fare, and baked apples, with sweet cream, may be used as a dessert. All spices and condiments, save a moderate quantity of salt, and all alcoholic beverages, are to be rigidly withheld, unless at times of great exposure or of marked exhaustion, when pure whiskey, well diluted, may be sparingly taken. Opium, cocaine, and other drugs which diminish gastric peristole, are to be forbidden, unless required to meet special indications. In the first days of the treatment the writer has often successfully employed a diet composed exclusively of predigested aliment, in the form of peptonised milk. A large part of the milk, being quickly transformed into peptones, is absorbed, and the objection usually urged against fluid foods—namely, their large bulk—is thus removed. When this plan is adopted, two or three quarts of peptonised milk are given daily, in divided doses, the intervals of drinking being from two to three hours. Leube-Rosenthal's beef solution and the so-called beef peptonoids of Rudisch are often of great value when milk

in any form is not well borne. When hardly any food is absorbed from the stomach, as in advanced hypertrophic gastrectasia, rectal alimentation may prolong life for some time. The *medicinal treatment* of gastric dilatation is not complicated. Digestion may be materially assisted by the judicious use of pepsin and dilute hydrochloric acid, given an hour after meals. Three grains of pepsin and five drops of the acid are fair average doses. The acid should be well diluted and gradually sipped, rather than taken all at once, if the patient's time will allow. Nux vomica or strychnine may be used if a tonic is indicated, and, aside from meeting this indication, it may render some service in increasing the contractility of the gastric muscles. Faradic electricity is also useful for the same purpose. It may be employed every day for five or ten minutes, both poles being applied to the epigastrium, or one pole to that region and the other to the lower dorsal region of the spine. If there be notable gastric acidity, with eructations, bicarbonate of sodium should be taken in twenty-grain doses, with water, ten minutes before meals. Constipation may be relieved by laxative enemata, or by a pill containing aloin, belladonna and strychnine. Ergotin, hypodermatically administered, has been recommended to stimulate gastric peristole, and an abdominal bandage, if not uncomfortably tight, may be useful in supporting the distended stomach. Abdominal massage improves the tone of the gastric and of the intestinal muscles. The constitutional condition of the patient claims attention. It will generally improve *pari passu* with the stomach. Mild preparations of iron, such as the carbonate, if well tolerated, may be used for anæmia. Patients should guard themselves against exposure, since their vitality is lowered and their powers of resistance impaired. They should be urged to exercise moderately in the open air, always within the bounds of slight fatigue, and should sleep seven or eight hours at night in well-ventilated rooms, resting, as much as possible, upon the right side. This position favors the emptying of the stomach, by allowing the contents of the organ to gravitate toward the pylorus.

Acute Dilatation of the Stomach.—This term has been applied to rapid overdistention of the stomach; supposed to be due to sudden paralysis of the gastric muscles and the consequent retention of all fluids and solids introduced into the stomach. The chief causes to which the overdistention has been referred are abdominal injuries, acute gastritis, acute peritonitis, fevers and boulimia. It is not certain that true paralysis of the stomach exists in these cases, nor has it been proved that chronic gastrectasia has not preceded the development of supposed acute dilatation. The symptoms usually stated to be characteristic of sudden overdistention of the stomach are severe gastric pain, gastric tympanites, cerebral anæmia, and the absence of emesis, or its cessation if it existed before the occurrence of acute overdistention of the stomach. The treatment of overdistention, whether suddenly or slowly developed, embraces lavage, as described in the section on gastrectasia, the use of foods both small in bulk and easily digestible, the employment of pepsin and of hydrochloric acid and the adoption of measures calculated to restore vigor to the atonic stomach.

Ulcer of the Stomach.—*Synonyms:* Perforating, chronic, round, peptic or digestive, eroding and simple gastric ulcer. The terms perforating, chronic, and round are not always appropriate, as many ulcers do not possess the characteristics described by these adjectives.

Frequency.—Gastric ulcer occurs very frequently, and, according to many authorities, is found, either open or cicatrized, in five per cent. of all autopsies.

Etiology.—Women between the ages of twenty and thirty are particularly liable to ulcer, and, in general, females are more often attacked than males, the proportion being, according to Brinton, as three to two. Men between thirty and forty are more liable to the disease than at other ages, while children are rarely affected. Ulcer is more common in anæmic, chlorotic, and enfeebled subjects than in strong and plethoric persons, and is more frequent in England and France than in the United States. Occupations which engender irritation of the stomach may predispose to gastric ulcer. Thus, cooks and knife-grinders, who swallow irritating substances, are said to lend a large contingent to the victims of the disease. Injuries of various kinds may constitute predisposing or exciting causes of ulcer, as will be explained under the heading *Pathogenesis.* Ulcers due to traumatism possess, as was shown by the experiments of Cohnheim, an unexplained tendency to ready healing, which does not belong to ulcers from other causes.

Pathogenesis.—Nearly all authors agree in regarding gastric ulcer as resulting from localized auto-digestion of the stomach-walls, and refer this auto-digestion to impaired circulation and nutrition in those areas which are the seats of the ulcerative processes. There are many divergent views regarding the nature and cause of the circulatory disturbance in the gastric vessels which is assumed to produce ulceration. Virchow holds embolism or thrombosis of the gastric arteries responsible for the vascular disturbances, but his view is not supported by anatomical evidence, as has been shown by Cohnheim, who, however, together with Panum, produced gastric hæmorrhagic infarction and ulcers, in dogs, by artificial embolic occlusion of the small gastric arteries. Klebs believes local spastic contraction of the arterioles to be the causative vascular condition. Other writers attribute the assumed circulatory disturbances to diseases of the gastric arteries, such as amyloid, fatty and atheromatous degenerations, to venous thrombosis, to vaso-motor neurosis and to excessive acidity of the gastric juice. Rindfleisch advanced the theory that the chief vascular disturbance leading to ulceration was generally hæmorrhagic infarction or venous hæmorrhage, the ulcer being produced, according to this theory, in essentially the same way as hæmorrhagic erosions. Rindfleisch's view, which has met with general favor, is supported by the experiments of L. Müller, who produced gastric hæmorrhages, hæmorrhagic erosions and ulcers, in rabbits, by obstructing the portal vein and the larger gastric veins. Various conditions may lead to the venous hæmorrhages supposed by Rindfleisch to cause ulcer, chief among them being spasm of the gastric muscles, by which the thin-walled veins are compressed and overdistended (Axel Key), varicose veins, passive congestion, and injuries, whether mechanical, chemical, or thermal. The nature of the changes in the mucous membrane dependent upon the above-named disturbances of the circulation, by which the membrane is rendered vulnerable to the attacks of the gastric juice, has also been the subject of long controversy. Pavy first formulated the theory that auto-digestion was prevented, during life, by the alkalinity of the blood coursing through the vessels of the gastric mucous membrane, by which the acid gastric juice was neutralized. In accordance with this view, impairment of the circulation would diminish the supply of alkaline blood, and the gastric juice would then be free to act upon the defenceless tissues. Pavy's theory is widely accepted, although not susceptible of absolute demonstration. It is, however, quite possible that some unknown vital property of the healthy gastric mucous membrane prevents auto-digestion, rather than the alkalinity of its contained blood, and that the loss of this property, from impairment of the circulation, facilitates the action of the gastric juice upon the enfeebled gastric tissues.

Pathological Anatomy.—Peptic ulcers are produced and extended by non-inflammatory, molecular necrosis, which, beginning in the mucous membrane, may involve only this and the submucosa, or may erode all the coats of the stomach. Peptic ulcers are situated in those parts of the digestive tract which are accessible to the gastric juice. Their favorite seat is in the pyloric region of the stomach, on the posterior wall, at or near the lesser curvature. Less frequently ulcers are seated in other regions, on the anterior wall, or at the greater curvature. They have been often found in the cardiac extremity and, rarely, in the œsophagus and in the duodenum. Welch analyzed a series of 793 gastric ulcers with reference to their seat, and found the ulcer at the lesser curvature in 288 cases,

on the posterior wall in 235, at the pylorus in 95, on the anterior wall in 69, at the cardiac orifice in 50, at the fundus in 29, and at the greater curvature in 27 cases. Usually there is but *one* ulcer, but two or more ulcers are found, according to Brinton's statistics, in twenty-one per cent. of all cases. The size of the ulcer varies from that of a pin-prick to a diameter of several inches. Delafield and Prudden give six inches as the maximum size. Cruveilhier described an ulcer six and one-half inches in length and three and one-half inches in breadth. The average size is that of a quarter of a dollar. The shape of the ulcer is commonly round, oval, or elongated, rarely annular, sometimes irregular, from the coalescence of neighboring ulcers. The loss of substance in the mucous membrane is ordinarily greater than in the deeper gastric tissues, so that a typical ulcer is of a peculiar funnel-shape, which is not, however, constant, particularly in old ulcers. The aperture in the mucous membrane is sharply defined in recent ulcers, as if a portion of the membrane had been removed by a punch. The various deeper layers can sometimes be distinguished by the varying extent to which they are eroded. Occasionally, however, the walls of the ulcer are both vertical, instead of being sloping, and sometimes they are swollen and infiltrated with blood. Virchow states that the most characteristic arrangement of the ulcer's walls consists in one side being vertical and the other sloping or terrace-like. Orth called attention to the direction of the axis of the ulcer, which is often not perpendicular to the mucous surface, but obliquely directed, as are the gastric arteries. The base of the ulcer is composed of one or the other coat of the stomach, unless complete perforation has occurred. In this case the base may be formed by the liver, by the pancreas, or by some other organ. The base of recent ulcers may be smooth and firm, soft, irregular, or hæmorrhagic, generally presenting no pus and being devoid of granulations. In old ulcers the base is often anæmic, even, and indurated, the edges being hard and elevated, from the development of new connective tissue. The tissues in immediate proximity to recent ulcers contain granular detritus, composed largely of amorphous remnants of connective-tissue fibres, of disintegrated red blood-corpuscles and of fatty granules. The tubules are often compressed and separated from each other by this granular matter. Some of the blood-vessels contain thrombi. Around the margins of the granular detritus is occasionally found a band of tissue infiltrated with lymphoid cells. The blood-vessels in the newly developed connective tissue have their walls thickened by endarteritis or by atheroma. They sometimes contain thrombi. The new tissue may develop in the mucous membrane, around the ulcer for a considerable distance, compressing or obliterating the gastric tubules, and causing inflammation and atrophy of the nerve-filaments. The ulcer frequently erodes blood-vessels in its wall or on its base, causing hæmorrhages which, according to the size of the vessels, may be trivial, dangerous, or even fatal. Serious hæmorrhages occur in only about one-third of the cases, and generally proceed from the splenic, the pyloric, the coronary, the gastro-epiploic, or the gastro-duodenalis vessels. Sometimes, however, grave hæmorrhage may come from erosion of the hepatic, pancreatic and mesenteric arteries and veins, or from varicose gastric veins. Peptic ulcers often heal spontaneously, leaving a cicatrix which is ordinarily stellate, and which often, in contracting, produces deformities of the organ or obstruction of the pylorus. In the former case the stomach may be divided into two unequal parts, and in the latter gastrectasia may result from the obstruction. Ulcers may coexist with cancer, and are often complicated by chronic gastritis. If an ulcer perforates all the layers of the gastric parietes, which occurs most frequently when the ulcer is situated on the anterior wall, the contents of the stomach may escape into the peritoneal cavity, producing rapidly fatal peritonitis; or if the perforation takes place slowly, local peritonitis is developed, and causes adhesions between the stomach and other organs which then form the floor of the ulcer. Under these circumstances the process of ulceration may invade these organs, especially the liver, producing irregular cavities and, occasionally, abscesses. The pancreas is not often deeply eroded. The ulcer may open into the pleura, the large or small intestine, the mediastinum, the pericardium, the left ventricle, the left bronchus, the common bile-duct, the pancreatic duct, the gall-bladder, the lung, on the surface, or into the portal vein. When perforation of this vein occurs, pylephlebitis is commonly the result. When the stomach communicates with the cavities of hollow viscera, or with the cutaneous surface, the channels of communication are called gastric fistulæ. Typhoid and tuberculous ulcers are rarely found in the stomach, but cases have been recorded in which they caused perforation and hæmatemesis. Necrotic gastric ulcers also sometimes occur in diphtheria, pyæmia and phlegmonous gastritis.

Clinical History.—In many cases gastric ulcers remain entirely latent throughout their course, as is proved by the post-mortem discovery of open or of healed ulcers in patients who have never presented any symptoms of the disease and have died of other complaints. Less frequently there are no symptoms until perforation suddenly occurs and induces fatal peritonitis or shock. In still another class of cases there are distinct symptoms, which are, however, not peculiar to ulcer, such as vomiting, eructations, anorexia and pyrosis. Generally, however, certain diagnostic symptoms are present, the leading ones being pain, localized tenderness and hæmatemesis. Pain is the most constant symptom of ulcer. The pain may be either continuous or intermittent, dull and gnawing, or lancinating, confined to one spot or radiating into various organs and members. The diffuse pains are not characteristic of ulcer, as they may be excited by gastritis or by various other causes. The kind of pain which, when present, is most characteristic of ulcer is circumscribed, gnawing or boring, generally epigastric or dorsal, or both, appearing soon after the ingestion of food, and generally ceasing when the food has been expelled into the duodenum or has been rejected by vomiting. This pain is therefore probably due to the chemical and mechanical irritation of the food and of the gastric juice. It is usually intensified by stimulating articles of diet, and by fermentations producing abnormal acids in the stomach, being lessened by bland aliments and by the neutralization of the abnormal acids with alkalies. When, as occasionally happens, the circumscribed pain persists after the expulsion of the gastric contents, it is probably due to localized peritonitis, to abscesses in neighboring organs or, in some cases, to an abnormal secretion of hydrochloric acid. The pain may sometimes be modified by position, the dorsal decubitus commonly affording relief when the ulcer is on the anterior gastric wall, and the prone position when the ulcer is located posteriorly. Pressure ordinarily increases, but, rarely, mitigates the pain. It is to be borne in mind that this pain may sometimes be entirely absent in cases of gastric ulcer. Circumscribed tenderness on pressure, corresponding to the seat of the ulcer, is a valuable and quite constant symptom. Pressure should, however, be carefully employed, as it has been known to cause perforation. Vomiting is another cardinal and fairly constant symptom, varying greatly, however, as to frequency, in different cases. Vomiting may be due to coexisting gastritis or to irritation by the ulcer. It may occur after cicatrization of an ulcer, from irritation of the stomach or from obstructive gastrectasia. Sometimes it occurs several times daily, and sometimes only once or twice a week. When present, emesis usually takes place soon after the ingestion of food, particularly if the latter be hot or possess irritating mechanical and chemical properties, and is preceded by pain. Occasionally vomiting occurs independently of eating and without premonitory discomfort. The act of emesis, although generally not violent, results in the complete evacuation of the gastric contents and in the relief or marked alleviation of the pain. The vomited matter contains portions of food, mucus, bacteria, sarcinæ, occasionally bile and sometimes blood. Hæmatemesis occurs in about twenty-five per cent. of all cases. This percentage does not accurately represent the frequency of gastrorrhagia, be-

cause slight hæmorrhages often occasion no vomiting, and the blood, being digested, does not appear in the dejections. Even when large hæmorrhages occur, there may be no vomiting, but merely more or less marked melæna. If hæmatemesis occurs after a moderate gastrorrhagia, the blood is generally acid, coagulated, and resembles coffee-grounds or tar. This appearance is due to the action of the gastric juice upon the coloring matter of the red corpuscles and upon the proteids of the plasma. If the hæmorrhage be very profuse, the vomited blood may be arterial in color, uncoagulated and of alkaline reaction. Several pints of such blood may be rejected at once. In about four per cent. of all cases the hæmorrhage is sufficiently profuse to induce fatal collapse. In such cases all the blood may, sometimes, be retained in the stomach, or only a small part of it may be vomited. The gross appearance of vomited matters which contain blood is ordinarily quite characteristic. In cases of doubt, the microscope or the spectroscope may be called into requisition. After hæmatemesis melæna may persist for several days. Perforation of the ulcer into the peritoneal cavity occurs in about six and a half per cent. of all cases, and is generally rapidly fatal either from shock or from acute peritonitis. Perforation is, in certain rare cases, the first and only symptom of an ulcer. Perforation occurs most frequently in females between the ages of fifteen and thirty years, the proportion of cases occurring in females and males being, respectively, as three to one. Ulcers on the anterior wall of the stomach cause perforation more frequently than those in other locations. When gases escape from a perforated stomach the liver, unless adherent, may be pressed backward and the normal hepatic flatness replaced by tympanitic resonance. If the perforation is small, it may cause localized peritonitis with adhesions to, and abscesses in, the various organs invaded, and generally proves lethal by exhaustion. In this way sub-diaphragmatic abscesses, simulating pneumo-pyothorax, may occur, or, adhesions between the stomach, the diaphragm and the pleura having taken place, the pleura and lung may be perforated and pulmonary abscess and gangrene excited, or pleuritis and pneumo-pyothorax induced. If the perforation occurs into the colon, fæces may be vomited. Rarely, the pericardium is invaded, and pericarditis results, or the portal vein is penetrated, and pylephlebitis with pyæmia follows. Perforation is usually caused by some sudden exertion, as lifting, coughing and vomiting, or by overdistention of the stomach with gas or food. The general symptoms in progressive ulcers are chiefly those of indigestion and the consequent malnutrition. The patients lose weight and strength, and, if hæmorrhage occurs, become more or less anæmic and œdematous. After large hæmorrhages this anæmia may become acute. The symptoms of chronic gastritis are commonly present. The bowels are ordinarily constipated and amenorrhœa is frequent. In some cases, however, there is hardly any interference with the general condition, and even the presence of large ulcers may not be incompatible with fairly good health. The cicatrization of ulcers may cause gastralgia, from traction upon the peritoneum, or it may lead to gastrectasia. Relapses, after apparent recovery from ulcer, are not rare.

Diagnosis.—Many gastric ulcers, presenting no diagnostic symptoms, necessarily escape observation. None of the cardinal symptoms of ulcer is absolutely pathognomonic, but, when associated, they usually render the diagnosis sufficiently clear to justify the adoption of measures adapted to the cure of ulcers. The characteristic features of the pain of ulcer are its localization, its aggravation by eating and by pressure, and its relief by evacuation of the stomach and by changes of posture. Hæmatemesis is the most important symptom of ulcer, and in young people should always excite suspicion of its existence.

The *differential diagnosis* lies between ulcer, gastralgia, chronic gastritis, cancer, hæmatemesis without ulcer and so-called biliary colic.

Gastralgia is not accompanied by tenderness, being rather relieved by pressure, and is paroxysmal, while the pain of ulcer is often continuous, and is aggravated by pressure. Eating does not usually excite simple gastralgia, but mitigates it. Vomiting is not so constant in simple gastralgia as in ulcer, and does not relieve the pain.

Hæmatemesis is not a symptom of gastralgia. The general health is often but little impaired in gastralgia, which often coexists with neuralgias in other organs. Chronic gastritis may be confounded with ulcer and, indeed, generally complicates the latter. Existing alone, it may even have all the cardinal symptoms of ulcer, but to a less degree. Thus, hæmatemesis is more rare, vomiting less common, and the pain less severe, more disseminated, and not paroxysmal. The results of treatment are less marked and speedy in chronic gastritis than in ulcer. The differential points between ulcer and cancer will be found in the remarks upon the diagnosis of cancer in the section on that subject. Hæmatemesis from various causes other than ulcer is to be excluded by careful attention to the history of each case (*vide* article Hæmatemesis in this HANDBOOK). So-called biliary colic, from the passage of biliary calculi, has some symptoms in common with ulcer, but the pain is situated in the right hypochondrium, and sometimes radiates to the right shoulder. The pain begins and ends abruptly, without reference to the ingestion of food. There is no epigastric tenderness. Jaundice is usually present. Biliary calculi are sometimes found in the dejections, after an attack. Sometimes the liver and the gall-bladder are enlarged in cases of biliary colic.

Prognosis.—It is estimated that about fifteen per cent. of all gastric ulcers end in recovery by cicatrization, the prospect for this desirable termination being good in proportion as the ulcer is superficial and recent, the patient's general condition good, and the treatment judicious. The causes of death are chiefly perforation, which ends fatally, according to Welch, in about six and a half per cent. of all cases; hæmorrhage, which is fatal in about four per cent. of all cases; and inanition, which is mainly responsible for the high average rate of mortality. Perforation, which is most common with ulcers on the anterior wall of the stomach, causes death by shock, by general peritonitis, or by localized inflammations. Yet some cases of slight perforation recover by the gradual subsidence of the resulting inflammatory complications, or by evacuation of abscesses. A profuse hæmorrhage is of bad prognostic import, betokening deep ulceration and causing anæmia, which itself predisposes to the development of new ulcers. Continuous pain, irrespective of the introduction of food, is an unfavorable symptom, pointing, together with a rise of temperature, to extra-gastric inflammation. Ulcers may be indirectly fatal even after their cicatrization, by causing gastrectasia, sacculation of the stomach, or, very rarely, rupture at the seat of the cicatrix. The duration of the disease is most uncertain, varying from a few days to many years. Brinton reports a case in which the ulcer continued open for thirty-five years, and several cases the duration of which was thirty, twenty, and fifteen years, respectively. The prognosis for a cure of old ulcers is naturally less favorable than for recent ones, since the fibroid thickening in the borders of the ulcers retards the progress of cicatrization. Relapses, after apparent complete cicatrization, are quite common, and carcinoma may develop from the floor of the cicatrix.

Treatment.—Whenever the symptoms are such as to render the existence of gastric ulcer even probable, appropriate treatment should be at once begun and persistently carried out. The objects of the treatment are to secure as absolute rest as is possible for the stomach, to prevent all chemical and mechanical irritation of the ulcer, to relieve pain, to prevent vomiting, and to check hæmorrhage, if these symptoms exist, to sustain the patient's strength, and to overcome his anæmia. The first two indications are best fulfilled by keeping the patient in bed, in that position which gives him the greatest comfort, and by withholding all food from the stomach. In some recent cases, the patients possessing a fair amount of strength, rectal alimentation may be exclusively employed for some weeks, and, in every case, it is desirable that no food be taken by mouth for at least several days.

Persistent vomiting and gastrorrhagia, at any period of the treatment, also naturally constitute urgent indications for rectal alimentation. The methods of preparing and of using nourishing rectal enemata, in cases of ulcer, are the same as those described under the treatment of gastritis, to which the reader is referred. The best materials for alimentary injections are Leube-Rosenthal's beef solution, Rudisch's beef peptonoids and peptonised milk. The last is prepared by means of Fairchild and Foster's peptonising tubes, to be obtained of any druggist. The quantity of these substances which the rectum will tolerate, and the length of the intervals between the enemata, can be best ascertained by trial. In general, from four to six ounces of fluid may be injected every three or four hours, a simple cleansing enema being also daily employed, and a few drops of the tincture of opium being added to each nutritive enema, for the purpose of obtunding the sensibility of the rectum and facilitating the retention of the enema. It would be advantageous to continue rectal alimentation until the evidences of complete cicatrization were obtained. In practice, however, this method is often objectionable, on account of aversion on the patient's part, and because it does not adequately sustain the vital forces. So soon, therefore, as these obstacles are encountered, rectal alimentation is to be supplemented or superseded by stomach-alimentation, unless pain and hæmorrhage absolutely contra-indicate feeding by the mouth. The foods recommended for rectal injection are also the best for use under these circumstances, and the writer gives the preference to peptonised milk. The food selected should be taken at intervals of two or three hours, and in small quantities. Urgent thirst may be quenched by cracked ice, in small pieces, dissolved slowly in the mouth. If none of the above-named foods be obtainable, sweet milk is the next best article of diet. Of this about two quarts should be given daily, and no other aliment employed for at least two weeks, unless there be considerable loss of weight and strength. Should emesis and pain return under this regimen, recourse must again be had to rectal alimentation. At the end of two weeks, or sooner, if the general condition of the patient demand more nourishment and there be no contra-indications, other articles of food may be experimentally employed. The qualities most desirable in these foods are blandness, concentration, softness and freedom from a tendency to fermentation. At first, raw eggs may be added to the milk and taken soft-boiled or poached ; then well-toasted bread, soaked in the milk, thoroughly boiled rice, or soda biscuits. Should a diet strictly limited to these articles be well borne, rare beefsteak, finely scraped, tender mutton-chop, thoroughly minced, stewed sweetbreads, cold roast mutton, raw or slightly cooked oysters, and the breast of chicken may be alternately used, in small quantities. Baked potatoes with fresh butter, cornstarch, sago, and tapioca cooked with eggs and milk, may also be allowed. All cooked fats, strong acids, spices and condiments, cheese, pickles, pastry, coarse and irritating foods such as cabbage and oatmeal, liquors, wines, and fruits, are to be carefully avoided. Violent exercise should not be taken. All these foods should be taken moderately warm, and should be *exclusively* used until cicatrization is believed to be complete, when the patient may gradually add any easily digestible foods to his *menu*. He should, however, ever after his attack, rigidly exclude all coarse, irritating, and indigestible aliments from his diet. A relapse should be the signal for an immediate return to the simplest foods or to rectal alimentation. Comparatively little can be accomplished by medicinal agents for the cure of ulcer. Great benefit is, however, often derived from the use of antacid remedies for the relief of pain due to the presence of abnormal acids, or of excessively acid gastric juice. The bicarbonate of soda fulfils this indication admirably when given in twenty-grain doses, before eating, or whenever the pain is felt. Bismuth subnitrate, in one-half-drachm doses, has rendered good services in some of the writer's cases, and seems especially beneficial in cases of ulcer complicated with chronic gastritis. These cases are most easily amenable to *lavage*, which, cautiously performed with the soft tube, can hardly do harm unless contra-indicated by great gastric irritability or by hæmatemesis. If lavage be employed, only about eight ounces of water should be slowly introduced at one time, and at once withdrawn, care being taken to secure the return of all the liquid. Ziemssen advocates the use of Carlsbad salts for the relief of the gastritis complicating ulcer. One or two drachms of the salts are to be dissolved in one-half pint or a whole pint of water at a temperature of 95° F., and one-fourth of this solution is to be drunk at intervals of ten minutes, the last dose being taken one hour before breakfast. Should the above quantity of salts not produce a loose movement after two or three hours, the quantity should be cautiously increased on the following days, until the desired result is obtained. Laxative enemata and the use of the soft tube are, perhaps, better adapted to cases of severe chronic gastritis, while the salts do well in milder cases. The pain of ulcer is best controlled by careful regulation of the diet and the use of alkalies according to the rules already given, or by temporary rectal alimentation. Gastralgia may be so severe as to require opiates, best given hypodermatically or by the rectum, which must, however, be withdrawn so soon as practicable, lest the opium-habit be engendered. Counter-irritation of the epigastrium is also useful. If constant pain, with fever, points to perigastritis or to local peritonitis, ice-bags may be applied. Vomiting is, likewise, most easily subdued by rest, mild diet, or, failing these, by rectal alimentation and opiates.

Hæmatemesis calls for rectal alimentation, rest, ice-bags to the epigastrium, and ergotin in solution, by the rectum or hypodermatically. For hypodermic use the following solution is appropriate :

℞. Ergotin, vel Squibb's ext. ergotæ. .. gr. xlviii.
Aquæ,
Glycerinæ...................... āā fl ℥ j.
M. Sig.—♏. 20 = gr. j.

Twenty minims of this solution may be injected several times, at intervals of a few hours. Twice the quantity may be given in warm water, at the same intervals, by the rectum. Morphine, hypodermatically administered, is also indicated. If the hæmorrhage be so profuse as to cause dangerous cerebral anæmia, brandy and ether may be given subcutaneously, ammonia inhaled, and transfusion performed. In the event of perforation, rectal alimentation, morphine, and warm fomentations are indicated, and, although not curative, serve to mitigate suffering and thus to promote euthanasia. Rydygier recommends laparotomy for perforation, and closing the ulcer with sutures. The same operator and Van Kleef and Czerny each successfully performed extirpation of a cicatrix which was producing pyloric stenosis and gastrectasia. Most physicians will, however, be content to treat gastrectasia by the method recommended in the section on that subject. The chronic anæmia resulting from ulcer is to be met with mild ferruginous preparations, well diluted, which should, however, be withheld until after complete cicatrization of the ulcer.

CANCER OF THE STOMACH. *Pathogenesis.*—Nothing is definitely known about the essential cause of cancer in general, and this statement of course applies with equal force to the origin of gastric carcinoma. Virchow advanced the theory that cancer results from long-continued normal or pathological irritation, and adduced the fact that the orifices of the stomach which are subjected to the greatest amount of friction are most frequently attacked, in support of his doctrine. Cohnheim's theory refers the origin of carcinoma to abnormalities in cellular development, and particularly to the persistence of embryonic cells. In accordance with this theory, pyloric cancer is most common on account of the complex development of that part of the stomach.

Frequency.—The stomach is, after the uterus, the most frequent seat of primary cancer. Many authors place gastric carcinoma first in point of frequency, but the carefully collated statistics of Welch show that one-third of all primary cancers are uterine and one-fifth gastric. According to Virchow, 34.9 per cent. of all cancers are

gastric, and 1.9 per cent. of deaths from all causes are due to this disease.

Etiology.—No occupation, injury, previous general disease, or mental condition has any etiological relation to gastric cancer. Age exerts a well-recognized causative influence. Three-fourths of all the cases occur between the ages of forty and seventy years, the largest number taking place between the ages of fifty and sixty. Gastric carcinoma is exceedingly rare in childhood, and infrequent after the seventieth year. Lebert concludes that hardly one per cent. of the cases occur before the thirtieth year, 16.3 per cent. between the sixtieth and the seventieth year, and 4.4 per cent. after the seventieth year. The cases are about equally distributed between the sexes, males being apparently rather more frequently attacked than females. Heredity exerts a causative influence. Welch states that in about fourteen per cent. of all cases it can be ascertained that relatives of the patient have suffered from the disease. Gastric cancer occasionally develops from a gastric ulcer, either open or cicatrized, which fact is of considerable practical importance. Cancer is said by Griesinger to be unknown in Egypt, and is also said to be rare in other tropical countries.

Morbid Anatomy.—A gastric cancer is most commonly situated at or near the pylorus, and generally on the posterior surface or at the lesser curvature. Welch analyzed 1,300 cases, with reference to the situation of the tumors, with the following results: Pyloric region, 60.8 per cent.; lesser curvature, 11.4 per cent.; cardiac extremity, 8 per cent.; posterior wall, 5.2 per cent.; the whole or the greater part of the stomach, 4.7 per cent.; multiple tumors, 3.5 per cent.; greater curvature, 2.6 per cent.; fundus, 1.5 per cent. Gastric carcinomata are usually primary, very rarely secondary. The varieties of gastric cancer are the cylindrical-celled, the scirrhous, the medullary and the colloid or alveolar. Combinations of these varieties often occur. Colloid cancer is the least common, and the cylindrical-celled the most frequent variety. The alveoli of cylindrical-celled carcinomata resemble the structure and arrangement of normal gastric tubules, the cells lining the alveoli being of cylindrical form. The consistency of this variety of cancer is soft. Scirrhous cancer is largely composed of a fibrous stroma, the alveoli being comparatively small. Scirrhus may be either nodular or diffuse, grows rather slowly, and does not so readily ulcerate as the other forms of cancer. Medullary cancer grows rapidly and readily occasions metastases. Its alveolar structure predominates quantitatively over the fibrous stroma, and it is consequently soft. It grows rapidly and ulcerates readily. Colloid cancer is either nodular, infiltrated, or annular. It is soft, the alveoli containing a clear, jelly-like substance, but it does not so readily ulcerate as the other varieties of carcinoma. According to Waldeyer, the origin of gastric cancer is in the mucous membrane, whence it extends to the submucosa and to the other tunics of the stomach. Sometimes the neoplasm is apparently seated in the submucosa, but careful search will show the tubules to be involved, connecting bands extending between these and the submucosa.

Ulceration occurs in three-fifths of all cases; most frequently, according to Lebert, in medullary, and least frequently in colloid, cancers. The ulcers vary in size, may be irregular or crater-like in form, and often show eroded or obstructed vessels in their base. Partial cicatrization of the ulcers sometimes occurs. Ulceration may reduce the size of cancerous tumors, and thus prevent or remove pyloric stenosis. If stenosis of the pylorus persist, gastrectasia ensues. Chronic gastritis usually accompanies carcinoma. Sometimes cancer causes atrophy of the stomach by obstructing its cardiac orifice. Progressive carcinomatous ulceration may perforate the stomach, causing hæmorrhage from erosion of the vessels, chronic adhesive peritonitis, or, more rarely, diffuse peritonitis. Violent gastrorrhagia and peritonitis from perforation are, however, less common with cancer than with ulcer. The ulcer may invade the pancreas, the liver, the diaphragm, the pleura, the pericardium, the spleen, etc., or it may establish fistulous communications between the stomach and the pleural, the peritoneal, or the pericardial cavities, and with the colon. Gastric cancer may also extend by metastasis through the lymphatics or the blood-vessels. The secondary growths are usually identical in structure with the primary neoplasm. The lymphatic glands near the stomach constitute the most frequent site of metastatic deposits, and next to these the liver, the peritoneum, the pancreas and the lungs, in the order named.

Clinical History.—As in gastric ulcer, so in cancer, particularly if it be secondary, there are sometimes no symptoms, death being due to intercurrent diseases. This rarely occurs, but shows that the duration of carcinoma cannot always be accurately estimated from the first unmistakable symptoms. In other instances local symptoms and signs referable to the stomach are trifling or absent, while emaciation, anæmia, and exhaustion are rapidly progressive. These cases are sometimes mistaken for phthisis, for Bright's disease, or for pernicious anæmia. In typical cases, however, there are symptoms and signs which are collectively diagnostic, namely, digestive disturbances, pain, emesis, hæmatemesis and a gastric tumor. Digestive disturbances, due to the neoplasm or to coexisting gastritis, are often the first symptoms. The appetite is impaired, perverted, or lost more frequently than in gastric ulcer. Sometimes, particularly if the cancer be at the cardiac orifice of the stomach, there is no loss of appetite. There are often epigastric discomfort, eructation, pyrosis, and nausea before the appearance of actual pain or emesis. Sooner or later, however, pain almost always becomes a prominent symptom. Brinton estimates that pain occurs in ninety-two per cent., and Lebert in seventy-five per cent., of all cases. It is probably most apt to be absent when the cancerous growths do not involve the orifices of the stomach. The pain may be either dull or lancinating, constant or paroxysmal. It is generally referred to the epigastrium, but often to the hypochondria, the loins, the mediastinum, the back, and even to more remote regions. The location of the pain does not, therefore, afford great assistance in exactly locating the cancerous tumor. When intermittent, the pain is frequently excited, and, when constant, is aggravated, by the ingestion of food. Pain is ordinarily more constant in the later stages of the disease, when ulceration has occurred, than at earlier periods of the malady. Vomiting occurs, according to Lebert, in eighty per cent. of all cases, appearing most constantly when either the pylorus or the cardiac orifice is diseased. In many instances emesis is rare, or absent, in the earlier stages, but begins or increases in frequency and violence as the disease advances. When the cancer is situated at the cardiac orifice, vomiting often, but not invariably, immediately follows the ingestion of food. In this case the food may not enter the stomach, but, encountering the cancerous obstruction at the cardiac orifice, is returned by reversed peristaltic movements of the œsophagus. In pyloric cancer vomiting usually occurs later than in carcinoma of the cardiac orifice, generally an hour or more after meals, but this rule has frequent exceptions. It is thus evident that the time when emesis occurs does not afford material assistance in locating gastric cancer. If gastrectasia has followed malignant pyloric stenosis, the vomiting naturally takes place after much longer intervals and is more copious, as is the rule in obstructive dilatation. The vomited matters consist, at first, of undigested food mingled with mucus and epithelium. Later, sarcinæ, torulæ, abnormal acids and gases are present, and in forty-two per cent. of the cases, according to Brinton, blood, which having been acted on by the gastric juice presents the familiar coffee-ground or chocolate-like appearance. In the majority of cases gastrorrhagia from cancerous ulceration is not profuse, the blood escaping from capillaries eroded by the process of ulceration. Commonly, however, the blood is present in sufficient quantities to be recognized by the naked eye, but in some cases an appeal to the microscope or the spectroscope may be necessary to decide the question. The spectrum produced by alkaline solutions of hæmatin shows an absorption band between C and D, which some-

times extends beyond D. The microscopic test for hæmin is made as follows: An excess of glacial acetic acid and a few grains of sodium chloride are added to the suspected liquid, and boiled in a test-tube. If blood-pigment is present, microscopic crystals of hæmin will be deposited by the cooled liquid, and may be recognized by their rhombic form and dark-brown color. Profuse hæmorrhages occur, according to Lebert, in only twelve per cent. of all cases of gastric cancer, men being more liable to them than women. Copious hæmatemesis is most often caused by soft cancers seated at the pylorus or on the lesser curvature, and generally takes place at a late stage of the disease. Gastrorrhagia may sometimes be fatal, and may even cause death, without occasioning hæmatemesis. Rosenbach recognized, in three cancer cases, fragments of cancerous structures in matters withdrawn from the stomach by the tube, and similar fragments have, very rarely, been seen by other observers.

Van der Velden claims that free hydrochloric acid is habitually absent in cases of gastrectasia from cancerous pyloric obstruction, but Seaman and others have detected hydrochloric acid in stomachs dilated by this cause, and the relative frequency with which this acid is absent in gastric cancer unaccompanied by dilatation remains to be ascertained. The view at present held by the majority of the profession, regarding this question, is apparently to the effect that habitual presence of hydrochloric acid in fluids taken from a dilated stomach renders the existence of cancer improbable. The absence of the acid cannot, however, be regarded as diagnostic of carcinoma, since it also occurs in chronic gastritis, in fevers and in other diseases. Rough clinical tests for free hydrochloric acid have been described under the treatment of chronic gastritis. There are, however, many sources of error in applying the more reliable and complicated tests for the detection of the acid, and it is therefore to be recommended that physicians employ competent chemists to make the necessary tests. The digestive power of the gastric juice is usually notably impaired in cancer cases, which naturally follows from the absence of hydrochloric acid. Riegel states that the gastric juice from a cancerous stomach, if added to normal gastric juice, even notably retards the action of the latter. The digestive power of gastric juice may be tested by suspending, in the filtered gastric fluids, a piece of fibrin, the temperature of the filtrate being maintained at about 100° F. If free hydrochloric acid is present the proteid will soon begin to dissolve. The most important sign of cancer in the stomach is a gastric tumor. This sign is never perceptible in the earlier stages, but can be discovered in about eighty per cent. of all cases at some period of the disease. Tumors placed at the cardiac orifice, at the fundus, on the posterior wall, or at the lesser curvature, near the pylorus, may escape observation, because hidden beneath the liver or behind the border of the ribs. If the neoplasm grows chiefly into the lumen of the stomach, it may likewise escape detection. In diffuse cancerous infiltration of the gastric walls no localized tumor is perceived, but a peculiar resistance and induration, corresponding to the seat of the stomach, may sometimes be appreciated. Pyloric tumors are felt more often than others. This is true partly because, even if a pyloric neoplasm be at first covered by the liver, it may later become palpable by displacing the pylorus downward. The tumor is ordinarily felt in the epigastrium, sometimes to the right and sometimes to the left of the median line, but may, owing to downward displacement of the stomach, be found in various other abdominal regions. In some instances the tumor is movable, changing its position according to the varying distention of the stomach and of the colon. When adhesions exist between the cancer and the liver or the diaphragm, the tumor follows the respiratory diaphragmatic movements. More frequently, however, the cancer is immovable, being fixed by adhesions. The tumor is generally small and nodular, occasionally smooth. Ulceration often causes perceptible diminution in the size of a tumor.

Percussion over the tumor occasionally yields a flat note, commonly, however, a dull one. The urine often has an abnormally small amount of urea and contains albumin, indican, and, according to V. Jacksch, diacetic acid, to which coma, occasionally observed at the end of cancer cases, is attributed by some authors. The bowels are ordinarily constipated, but often constipation alternates with diarrhœa. The temperature is often normal during the entire course of the disease. Sometimes, however, there are slight chills, followed by elevation of temperature. As death approaches, the temperature may become subnormal. Cancer of the stomach causes marked anæmia, extreme emaciation and great asthenia, and imparts a more or less characteristic color to the skin. This cachectic appearance is not pathognomonic of carcinoma, as it may occur in non-cancerous pyloric stenosis and in ulcer. Thromboses of the veins of the thigh and leg are common, but hydræmic œdema of the feet and legs may occur independently of this. Dysphagia occurs in many cases, chiefly when the cancer involves the cardiac region of the stomach. The patient's mental powers are generally not impaired by the disease, but he is usually depressed and melancholy. Gastric cancer may perforate the stomach, causing peritonitis or any of the inflammatory complications and fistulous communications mentioned as possible results of perforation by an ulcer. Gastro-colic fistula is more common with cancer than with ulcer. Perforation of the stomach occurs much more rarely with cancer than from ulcer. Fatal gastrorrhagia from erosion of blood-vessels occurs in only about one per cent. of all cases of gastric cancer. The symptoms due to metastatic cancerous tumors of the liver, of the peritoneum, of the lymphatic glands, of the pancreas and of the lungs are to be sought in the articles in this HANDBOOK devoted to these respective subjects.

Differential Diagnosis.—This involves the exclusion of other gastric diseases and of tumors not connected with the stomach. The gastric diseases most likely to be mistaken for cancer are ulcer, simple chronic gastritis, chronic interstitial gastritis, gastrectasia from non-malignant pyloric stenosis, gastralgia, and other gastric neoplasms. The chief points of distinction between gastric cancer and ulcer are the following: The age of patients with ulcer is under forty in about one-half the cases, while cancer is rare until after the fortieth year. In cancer, vomiting is less frequent than in ulcer, and commonly occurs later after the ingestion of food. Gastrorrhagia is more frequent in cancer, but less profuse. In cancer the vomited matters may contain cancerous fragments and be devoid of hydrochloric acid. The pain of cancer is more constant, is less affected by eating, is more diffuse, and is less relieved by emesis than that of ulcer. A gastric tumor is present in eighty per cent. of cancers of the stomach, but a tumor is rare with ulcer. The maximum duration of cancer is about a year and a half; that of ulcer may be much longer. Appropriate treatment commonly relieves the symptoms of ulcer, but not those of cancer. The cachexia of carcinoma is more marked, and not so directly referable to the gastric symptoms. Secondary growths are often found in other organs with cancer, but not with ulcer. The fact is to be constantly borne in mind that a cancer may develop from the margins or from the cicatrix of an ulcer, in which case the clinical history of the latter gradually merges into that of the former. In simple chronic gastritis the vomited matters frequently contain hydrochloric acid and never cancerous fragments; gastrorrhagia is rare, and the pain is both less severe and less localized than in cancer. Gastritis occurs at all ages indifferently, has no tumor, and may continue indefinitely, but is more readily controlled by treatment than is cancer. Gastritis produces no marked cachexia, and is not attended by secondary growths. Chronic interstitial gastritis sometimes presents a smooth, resisting tumor, possessing the shape and outlines of the stomach, but can hardly be differentiated from diffuse gastric cancer. It generally tends to diminish the size of the stomach, is of longer duration, and is usually not accompanied by gastrorrhagia or by severe pain. Simple gastralgia generally has none of the symptoms of carcinoma except the pain. Gastrectasia following non-malignant pyloric obstructions is ordinarily due

to antecedent ulcer, the history of which may be obtained. It also commonly occurs before forty rather than after that age. The other gastric neoplasms are so rare that they are clinical curiosities, and their differential diagnoses need not be discussed. If they are so situated as to cause pyloric stenosis, they can hardly be distinguished from cancer. The tumors of other organs most likely to be mistaken for gastric cancer are those of the liver, the pancreas, the peritoneum, the aorta, the intestine, the retroperitoneal lymphatic glands and the omentum. Even renal and splenic tumors may be included in this category. For the differential diagnosis of these neoplasms the reader is referred to the writer's article on Abdominal Tumors, in the first volume of this HANDBOOK. The diagnostician should always bear in mind the possibility that secondary cancerous tumors, developing in any of these organs, may quite obscure the original gastric carcinoma. It is usually impossible to diagnosticate the variety of cancer existing in a given case, nor is it especially useful to make the distinction. In very rare cases the variety of cancer may perhaps be ascertained by an examination of the carcinomatous fragments found in the fluids withdrawn from the stomach.

Prognosis and Duration.—There is no authentic record of recovery from gastric cancer. Billroth successfully performed pylorectomy for gastric carcinoma in 1881, and the operation has been successfully done several times since then. In the majority of the cases, however, the operation has been fatal, and in no case has an ultimate cure been effected, although life has undoubtedly been considerably prolonged by this surgical interference. It is possible that a radical cure may sometimes be attained by early pylorectomy in favorable cases, but the diagnosis is so frequently in doubt until secondary deposits have occurred that there is little probability of a decided reduction in the mortality of gastric cancer by operative treatment. The duration of gastric carcinoma can often only be approximately estimated, because the disease frequently remains latent for a long time. On the other hand, in cancers developing from ulcers the carcinoma may be regarded as the original disease, and a correspondingly long duration be ascribed to it. Lebert estimates the average duration at fifteen months, and the maximum duration at four years. Brinton places the average duration at twelve and a half, and the maximum duration at thirty-six months.

Treatment.—There is no known specific for gastric cancer, and all treatment must consequently be symptomatic. The indications are, as in ulcer, to prevent gastritis by bland aliment, to relieve pain, to check emesis and to control hæmatemesis; to sustain the patient's strength, and to meet other symptomatic indications as they arise. The most suitable articles of diet are those recommended under the treatment of gastric ulcer. Pain is to be relieved by morphia, preferably given hypodermatically. Vomiting is to be checked by opium, counter-irritants, a regulated diet, and, if otherwise uncontrollable, by rectal alimentation. Hæmorrhage, if profuse, and perforation require the same treatment suggested for pain and gastrorrhagia from gastric ulcer. The same remark applies to inflammatory complications of abdominal or thoracic organs. Constipation calls for laxative enemata, and diarrhœa for opium and bismuth, or for starch and laudanum enemata. For pyrosis, alkalies are valuable. Lavage, by means of the soft tube, unless contra-indicated by profuse gastrorrhagia, or by great asthenia, is useful in relieving gastritis and in preventing the development of gastrectasia. Operative interference, to be of avail, must be undertaken early, before glandular infiltration has occurred. If an early and reasonably certain diagnosis of cancer is made, it is justifiable to perform laparotomy, in order to decide upon the propriety and necessity of an operation. In the hands of experienced surgeons this laparotomy is devoid of serious dangers.

OTHER GASTRIC NEOPLASMS.—The most common non-malignant gastric new-growths are mucous or submucous adenomata and myomata. Fibromata, lipomata, cystomata and miliary aneurisms are rarely observed. Primary or secondary sarcomata and myo-sarcomata are also infrequent. These neoplasms have little clinical significance, owing to their rarity and to their ordinarily small size. The differential diagnosis between carcinoma and these new-growths cannot ordinarily be made with any certainty, and their treatment, when recognized, is the same as that recommended for cancer.

ATROPHY OF THE STOMACH AND DEGENERATION OF THE GASTRIC TUBES.—Atrophy of the entire stomach, from disuse, may follow stenosis of the œsophagus or of the cardiac orifice. The general atrophy of marasmus and of senility may also involve the stomach. The gastric tubules frequently undergo parenchymatous and fatty degeneration in the acute infectious diseases, such as typhus and typhoid fevers, yellow fever, septicæmia, and the eruptive fevers, and in poisoning with phosphorus, arsenic, mercury and the mineral acids. The tubules are gradually restored to their natural condition after the subsidence of these febrile disorders or the elimination of the poisons causing the degenerations. It is reasonable to assume that the digestive disturbances observed in cases of the above maladies are in large measure due to failure in the functional activity of the gastric secreting cells. Allusion has been already made, in the appropriate sections, to the degenerative and atrophic changes in the tubules accompanying chronic gastritis, interstitial gastritis, phlegmonous gastritis, ulcer and carcinoma. As early as 1860, Dr. A. Flint, Sr., advanced the opinion that degeneration of the gastric tubules would prove to be the anatomical basis of certain cases classed as pernicious anæmia. The subsequent investigations of Fenwick, Quincke, Brabazon and others support this view. In some of the recorded cases the atrophy has been attended by increase of the interstitial gastric connective tissue, but in other cases this was wanting. The absolute demonstration of the existence of primary atrophy of the tubules has, however, in the writer's opinion, not yet been furnished. The general symptoms which have been referred to atrophy of the gastric tubules are those of pernicious anæmia, the digestive symptoms being anorexia with occasional vomiting, eructation and epigastric pain. It is exceedingly difficult, in these cases, to decide whether the anæmia may not have caused sufficient disturbance of nutrition to produce the local atrophy, rather than that the reverse conditions obtained. This is one of the problems now engaging general attention on the part of the profession, and which it is to be hoped may eventually meet with a satisfactory solution.

RUPTURE OF THE STOMACH.—Perforation of the stomach may occur, as has been stated in the appropriate sections, from diseases affecting its parietes, such as ulcer, cancer, toxic gastritis and suppurative gastritis. Rupture of a healthy stomach may occur from severe abdominal injuries, with or without perforation of the abdominal walls. Thus, heavy weights falling from a height, the wheel of a heavy vehicle—or the buffers between railway carriages—being brought violently in contact with the abdomen, may rupture the stomach in common with other viscera, or, in rare cases, the stomach alone. There are no satisfactory records of spontaneous rupture occurring in a stomach with healthy walls, although many cases of supposed spontaneous rupture have been reported. In the majority of these cases the pathological anatomical conditions were not carefully investigated, and it is probable that pre-existing lesions were responsible for the accidents. Leube performed experiments upon the cadaver in order to test the resisting capacity of the stomach, and found that enormous distention of the organ could be produced by hydraulic pressure without occasioning rupture. In these experiments the mucous membrane and the serosa yielded to the pressure, while the muscular coat remained intact. The writer has seen a case of atonic gastrectasia in which the distention of the stomach was such as to cause intense suffering, with extreme tenderness over the organ, which reached to the iliac crest. In this case the pain and the other symptoms were such that rupture was regarded as imminent, and the tube was at once introduced. After the escape of an immense amount of gas the pain at once

subsided, whereupon nearly three gallons of liquids and solids were withdrawn by the siphon. The symptoms of rupture of the stomach are identical with those of perforation, already described. The prognosis is fatal, and the treatment must consist in the free administration of morphine hypodermatically, with a view to promoting euthanasia.

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STOMATITIS. This word, which from its derivation signifies inflammation of the mouth, is held to include inflammatory affections of the cavity of the mouth as far back as the soft palate. Any abnormal condition of an inflammatory character which involves the gums, the tongue, or the inner surface of the cheeks, is included, therefore, under the designation of stomatitis. Experience shows that there is little tendency toward limitation to any one of these structures—usually the entire cavity of the mouth partakes of the diseased condition.

The affections included under this name are, in great part, limited to the age of childhood. Adults are never the subjects of certain forms of the disease, and seldom suffer from any variety of it, save as part of some other morbid condition. Not infrequently, however, stomatitis is nothing more than a part of such general condition. Diphtheria sometimes involves the mouth as well as the tonsils, pharynx, and palate; inflammation, with pustulation in the mouth, may occur in small-pox, varioloid, and varicella; facial erysipelas often presents an inflamed condition of the mouth; measles, Rötheln, and syphilis are accompanied by characteristic mouth affections; and many drugs, such as mercury and iodine, in addition to the mineral and other stronger acids, produce an abnormal condition.

These various conditions do not come within the province of the present article, and for their consideration the reader is referred to the articles treating of the various diseases mentioned.

What may be called primary stomatitis, as distinguished from the above-mentioned conditions, being practically a distinct disease, is encountered in the following varieties:

I. Simple, catarrhal, or erythematous.
II. Membranous, or ulcero-membranous.
III. Ulcerative.
IV. Gangrenous.

I. CATARRHAL STOMATITIS.—By this we mean that form which does not present exudation or ulceration. It is seen occasionally as a result of taking cold, being part of a general inflammation of the respiratory mucous membrane; it is sometimes associated with chronic alco-

holism; it may be caused by excessive eating of acid fruits and highly seasoned articles of food; and in children it is frequently an attendant upon difficult dentition.

Its symptoms are: Redness and capillary injection of the mucous membrane; swelling of the tongue, cheeks, gums, and lips; dryness of the cavity of the mouth, especially at first, and later sometimes increased flow of saliva and mucus, especially in the case of teething children. If the swelling, which is flabby, be marked, the impression of the teeth may be seen on the tongue and cheeks. The sense of taste is often diminished, and is sometimes perverted—patients stating that meats, etc., have a putrid flavor. The amount of pain is not great in this variety of the disease, and is often entirely absent, particularly in the chronic stomatitis of excessive drinkers. Occasionally the salivation is a source of annoyance, as in the stomatitis of difficult dentition.

As to treatment, over and above that addressed to the causative agency, the means to be used are the moistening of the mouth with cold water, the administration of chlorate of potassium, and often the application of astringent washes, such as a weak solution of sulphate of zinc or copper.

II. Membranous, or Ulcero-membranous Stomatitis.—Diphtheritic membrane may involve the anterior aspect of the soft palate, and sometimes spreads forward over the cheeks and tongue. Thrush, which is characterized by the formation of a white pellicle or membrane in patches, is most frequently visible on the tongue. Both these diseases are certainly membranous forms of stomatitis, but the term is here employed to indicate an affection distinct from these, and local in its nature. Diphtheria and thrush are described elsewhere in this work.

Ulcero-membranous stomatitis, in this restricted sense, is a disease characterized by the production of discrete patches of thick, yellowish, pseudo-membrane or exudation, which apparently becomes separated from the subjacent tissues by an ulcerative process, leaving erosions on the surface formerly occupied by the exudation.

As to causation, it is to be attributed to bad hygienic surroundings, to improper and insufficient nourishment, and is generally met with in hospital patients, and but very rarely among people in more comfortable circumstances. It has clearly an epidemic character, as usually a number of cases will be encountered at or near the same time; and, on the other hand, long periods will elapse without the occurrence of a single case. Convalescence from acute diseases is thought to be a condition predisposing to its occurrence.

Like other forms of stomatitis, it is in the main an affection of childhood, though not of infancy; the usual time of its occurrence being between the ages of five and ten years.

The disease generally begins with pain and discomfort in the gums, made prominent by the act of mastication. The gums are seen to be reddened and swollen, and are tender to the touch—in short, a condition of gingivitis is present. There is commonly a slight rise of temperature. Then a grayish or yellowish exudation makes its appearance on the gums, which spreads to the adjacent parts of the cheeks and inner surface of the lips; and occasionally even involves the palate and pharynx. If this pseudo-membrane be detached, the subjacent mucous membrane is found to present an excoriated and ulcerated appearance.

If the case be a mild one, the area covered by the exudation is not great, the ulcerations are neither large nor deep, the other symptoms are not severe, the course is rapid, and complete restoration to the normal condition occurs within a few days.

On the other hand, in a severe case the exudation spreads widely, the ulcerations become deep, foul, and extensive; the breath is offensive, the odor sometimes being almost gangrenous; the saliva is greatly increased in amount, is offensive in odor, and discolored; the salivary and submaxillary glands become enlarged and tender, and the swelling, stiffness, and pain in the jaws are marked. Such a case may be protracted for a month or more, and may closely resemble true gangrenous stomatitis—possibly may run into that disease. The similarity between the two conditions may be very great, and the points of difference in the matter of diagnosis will be mentioned below, in the description of the latter disease.

The prognosis is favorable, even in the severe form, if true gangrene do not supervene.

The treatment is, in the first place, to be addressed to the general condition of ill-health spoken of as having a causative relation. Nourishment, of good quality and quantity, should be first provided for; stimulants may be necessary; tonics, as the compound tincture of cinchona or the tincture of nux vomica, are usually of considerable assistance; and the administration of iron is advisable. As to local treatment, the most serviceable drug is the chlorate of potassium, which should be given in considerable quantity—two or three grains every two or three hours. In addition to this, local astringent washes, as a solution of sulphate of copper (five grains to the ounce), or the honey of borax, should be used freely. Chloride of lime is highly spoken of as a cleansing agent.

III. Ulcerative inflammation constitutes an essential part of the variety of stomatitis just described, and, as will be seen, is also present in the gangrenous form. Ulceration occurs also in aphthæ, and in children this is by far the most frequent form of ulcerative stomatitis. Finally, small ulcerations are formed by the breaking of herpetic vesicles, which occasionally appear in the mouth as well as on the lips. These are popularly known as "canker sores," are always small in size, and remain but a short time. To touch them once or twice with solid sulphate of copper or nitrate of silver is sufficient to cause them to heal readily and quickly.

IV. Gangrenous Stomatitis.—This grave disease has a variety of names, the two in most frequent use being cancrum oris and noma; it is occasionally called cancer aquaticus, or water cancer.

It is a true gangrene or sphacelation, affecting the jaws and cheeks, and sometimes spreading widely and with great rapidity. It occurs, like the ulcero-membranous form of stomatitis, in children only, and in those in bad general condition and living in bad hygienic surroundings; and, in the great majority of cases, develops during convalescence from some one of the acute febrile diseases. Of such antecedent affections measles is the most frequent; it being estimated that one-half the cases follow this disease. Pneumonia, though very often a concomitant of the gangrenous disease itself, sometimes precedes it, and typhus fever is said to be occasionally followed by gangrenous stomatitis. It is asserted by some that the affection may become developed in severe forms of mercurial sore mouth, but such instances must be rare, for mercurial ptyalism is usually amenable to treatment. Sometimes it is encountered in such a manner as to appear to be epidemic; in this bearing some resemblance to hospital gangrene.

It is an affection of childhood, occurring in the period of second dentition, and is rarely, if ever, seen in a child under one or two years of age, or over ten or eleven.

The disease is generally unilateral—not extending across the middle line of the lips. It is considered by many to be independent of thrombosis or embolism of the blood-vessels, such as causes gangrene elsewhere, and under different conditions. Yet there must be, seemingly, some circulatory disturbances to account for it, since the unilateral character is almost invariable; from which we may reasonably argue that the circulation on the unaffected side is maintained in proper degree, while the death of tissue on the diseased side is evidently due to defective nutrition. Moreover, after death the arteries are found to contain more or less firm clots, and before death hæmorrhage does not occur when a vessel is opened by erosion.

Gangrene of the mouth does not begin with active inflammation, and absence of pain is quite characteristic; often the existence of the disease is not suspected until the destructive process has become far advanced. If seen

at the outset, its first appearance is that of a vesicle or bleb, which soon breaks, leaving an ulceration on the gum or inner surface of the cheek, or frequently at the line of junction of the two. Some degree of swelling of the face soon shows itself, the breath almost immediately becomes fetid, and soon acquires a gangrenous odor. With the bad general condition there is but little fever or pain, and a pronounced condition of prostration does not develop at once. On the contrary, the child usually sits up and takes its nourishment quite readily. The foul ulceration spreads, often with great rapidity, and soon the substance of the cheek presents a circumscribed, hard, tense, and shining swelling or infiltration, of a dark red color, with one or more bluish spots soon appearing—which are in reality dead tissue. Sometimes only two or three days are needed for this condition to be attained. The saliva is increased in quantity, is blood-stained and dark, and most offensive in odor; and the submaxillary and salivary glands become enlarged. Thirst is constant, and is most distressing to the patient, and often an exhausting diarrhœa, difficult to control, sets in, increasing, of course, the prostration.

The intelligence remains generally undisturbed, and the little patients do not seem to be greatly alarmed, but rather apathetic. The temperature and respiration become influenced principally because of, and in proportion to, pneumonic inflammation of the lungs, which, as stated, is frequently a precedent and concomitant condition. This associated pulmonary inflammation is, however, never of the sthenic type of simple acute lobar pneumonia.

The appearance of an eschar on the skin of the cheek, usually at or near the angle of the mouth, is characteristic, and is an indication of the extension of the gangrene through the thickness of the cheek. This may occur in as short a time as two or three days. The eschar continues to spread, and may, indeed, advance with such rapidity that from three to six days suffice for the destructive process to be complete. Such rapid progress is not, however, the rule, and ordinarily the entire duration is from one to two weeks in cases terminating in death, which almost always occurs.

Together with the sphacelation of the soft parts, necrosis of the maxillary bones takes place. The bone becomes diseased, and presents a worm-eaten appearance, and the teeth loosen and can be removed from their sockets. The tongue, however, remains uninjured.

Profuse hæmorrhage is very rare, though there is always some oozing of blood, which discolors the saliva. As stated, the arteries are found after death to contain clots of considerable firmness.

When the disease has advanced, the odor of the patient's breath is more than fetid and offensive—it is distinctly gangrenous.

Recovery is a remarkable event, occurring, according to most authorities, in about one case in twenty. If the characteristic eschar appear on the skin of the cheek, very little hope can be entertained.

Death occurs from asthenia, after a duration of from one to two weeks, and is often hastened by the lung inflammation which so frequently occurs. In the few cases which recover, the disease is greatly prolonged, and after the final healing of the affected part much cicatrization and disfigurement remain.

A similar gangrenous disease, in rare instances, invades the genital region in girls (noma vulvæ), and runs the same severe course, with generally a fatal termination.

The diagnosis of gangrenous stomatitis is usually not difficult. The conditions bearing a resemblance to it are: The bad form of ulcero-membranous stomatitis, and serious and aggravated cases of mercurial sore mouth. From the former, discrimination is to be based on the absence of pseudo-membrane, the rapid and deep extension of the ulcerative process, the perforation of the cheek, and the hard, smooth, dark, and shining swelling. Also, in the simpler disease, no necrosis of the jaw nor loosening of the teeth occurs. Ulceration from mercurial poisoning has an antecedent stage of salivation, is bilateral, and does not spread rapidly and extensively, nor does it perforate the cheek like gangrenous stomatitis.

The treatment of gangrenous stomatitis, though not satisfactory, must yet be energetic. It consists of general and local measures. The former include the carrying of nutrition to the highest possible point, by urging the patient to drink most freely of milk and cream of good quality; to take concentrated fluid preparations made from meat; and, if it can be done without interference with digestion or discomfort in eating, to take bread and farinaceous articles of food. Stimulants are almost always admissible from the first, and generally have to be given with a free hand. A child five years of age can take two teaspoonfuls of brandy every two or three hours, and if the prostration be great, a still larger quantity. The better plan is to give the liquid nourishment in stated quantities at intervals of about two hours, so that one or two quarts of milk are administered in the twenty-four hours.

The principal part of the local treatment consists in the thorough application of cauterizing agents to the diseased surface. The earlier and the more thoroughly this is done, the better is the chance (slight though it is) of altering the character of the eroded surface, and converting it into a simpler form of ulcerative process.

The agent most frequently used is nitric acid, applied over the entire diseased surface, the surrounding healthy tissues being protected by oil or vaseline. The application must be thorough to be of any value, and the utmost care is necessary to prevent injury to the sound parts. The mouth should be carefully and copiously syringed out with water after the cauterization. Other escharotics, as muriatic and pure carbolic acid, can be employed, as well as the actual cautery or galvano-cautery. Usually authorities advise frequent cauterization—sometimes as often as twice a day—but, on the other hand, the statement has been made that no greater proportion of recoveries results among those treated by this means than among those in whom it is not resorted to. It should, however, be looked upon as a plan of treatment affording at least a chance of recovery from what is almost a hopeless disease.

In addition, constant antiseptic washing of the mouth should be enforced, since a part at least of the asthenic condition and prostration can be attributed to septic absorption. Simple salt and water, weak solutions of carbolic acid, of bichloride of mercury, or of boracic acid, should be liberally used. Chlorate of potassium and the tincture of the chloride of iron should also be given.

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Thomas D. Swift.

STORAX (*Styrax*, U. S. Ph.; *Styrax Præparatus*, Br. Ph.; *Styrax Liquidus*, Ph. G.; *Styrax liquide*, Codex Med.). "A balsam prepared from the inner bark of *Liquidambar orientalis* Miller; Order, *Hamamelaceæ*."

This is a bushy, middling-sized tree, resembling a maple or plane tree, with smooth, purplish-gray bark, and maple-like, lobed, smooth, stipulate leaves. Flowers minute, the sterile of numerous stamens only, the fertile of a short calyx-tube and two several-ovuled carpels. They are arranged in compact globose clusters, which, as they ripen, form compound fruits of the coalescing calices and pistils.

This tree is a native of the Southwest districts of Asia Minor, where it forms forests. Its range seems to be quite a small one, not extending to the north or to the islands of the Levant.

The name Storax (Styrax) has for many centuries been applied to two quite distinct substances: The resin of *Styrax Officinalis* Linn., a solid, benzoin-like balsam which has become obsolete, and the present complex liquid called for distinction Liquid Storax. This is collected by removing the outer bark from the tree, then scraping off the inner bark and boiling it with water from the sea. The resin melted out from the bark separates from the watery liquid and is skimmed off. The bark is then pressed and a further amount obtained.

Storax prepared in this way is a soft, resinous compound

FIG. 3735.—Storax: leaves and flowers. (Baillon.)

of peculiar balsamic, agreeable odor, having a honey-like consistence and a pungent, burning taste. It is opaque, of a grayish-brown color, and contains considerable water entangled in it, to which its opacity is due. Upon long standing or heating the water may be driven off, and a clear yellow or brown resin remains behind. In odor it improves with age. It always remains sticky. This balsam consists principally of an amorphous substance named *storesin*. It also contains several *cinnamic ethers* and *cinnamate of cinnamyl* (styracin), which can be prepared in rectangular prisms, and *cinnamic acid* and *styrol*.

Storax goes principally to the East, very little being used in European pharmacy; in its action it varies very

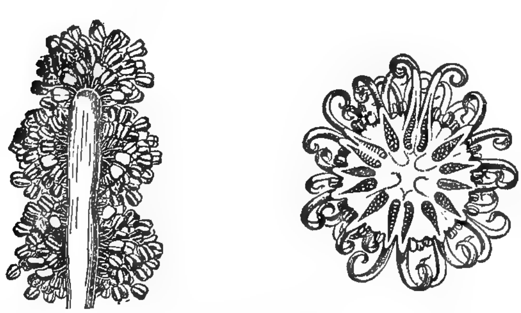

FIG. 3736.—Storax; staminate and pistillate clusters enlarged. (Baillon.)

little from a number of other resinous substances; internally it has been used in bronchitis and similar conditions with but moderate success. As an ingredient of liniments, ointments, etc., it is quite useful. The compound tincture of benzoin contains eight per cent. of storax. Dose of storax, from three to five drops.

ALLIED PLANTS.—The Sweet Gum Tree, *Liquidambar Styraciflua* Linn., resembles the above species and supplies a non-drying sticky resin resembling storax in medicinal properties, although not in color or opacity. *Hamamelis Virginica*, Witch-Hazel, belongs to a related Genus.

ALLIED DRUGS.—Numerous balsams, resins, turpentines, etc., resemble this in their action; perhaps the nearest is *Balsam of Peru*, q. v. *W. P. Bolles.*

STRABISMUS, or **SQUINT**, is that condition in which the visual axes are not both directed toward the point looked at; its peculiar subjective symptom is diplopia, and objectively the eyes may be seen to be turned in different directions.

Diplopia arising from strabismus is binocular, and is noticed only when light from the object looked at falls on both eyes and is sufficiently well focussed by both to form a sensible image on the retina; when both retinal images cause the proper impression on the visual centres; and when these visual centres are so related to each other as to possess the power of binocular fusion. If, when one eye is excluded from vision by closing it or covering it with an opaque object, the double vision still remains, it is monocular and has nothing to do with strabismus.

Normally, when a certain point is looked at, or fixed, the visual axes of both eyes pass through that point and in each eye its image falls on the retina at the fovea centralis; and the impressions thus received produce in consciousness the idea of a single point. When, however, the point looked at makes its impression on the fovea in one eye, but on some other portion of the retina in the other, it generates the idea of two distinct points some distance apart, the impression on the fovea being referred to a point directly in front of the eyes, while the impression on another part of the retina is referred in a different direction, giving rise to the idea of the duplication of the point looked at, called diplopia or double vision. Thus in Fig. 3737, representing a case of convergent strabismus, the visual

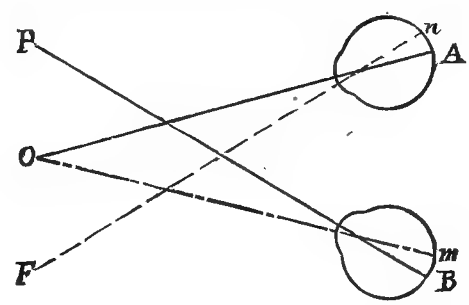

FIG. 3737.

axis of the eye A being directed to the object O, the visual axis of the eye B is directed elsewhere to P.

In the eye A the impression of the point O will be made at the fovea; but in the eye B the light from O, entering in the direction of the broken line O *m*, will make its impression on the point *m*, some distance from the fovea. Since the impression is made on A at the fovea, it will be correctly referred to the object looked at. But in B the impression made at *m* will be referred to a point to one side of the object looked at; its position relative to O being in the direction *n* F, which makes the same angle with the visual axis of A as O *m* makes with the visual axis of B. The image of the point received on A, and referred to its true position O, is called the *true image*. The image received at *m*, and referred to F, in the direction *n* F, is called the *false image*.

In Fig. 3738, representing what occurs in divergent squint, the eye A, turned toward the object O, receives on its fovea the true image, which is referred to its proper source; and the eye B receives at *m* the false image, which, with reference to the true image, is referred in the direction *n* F to F.

In either case, when the deviating or squinting eye is turned to the right, the false image appears to belong to an object to the left of that which causes the true image;

and when the deviating eye turns to the left, the false image seems to be to the right of the object. When an eye deviates upward its false image appears below; and when it deviates downward the false image appears above. In general, in whichever direction the squinting eye deviates, its false image appears to be situated to the opposite side of the true one. When the image on the right side belongs to the right eye, it is called *homonymous diplopia*. It occurs when the visual axes are crossed as in Fig. 3737. When the image on the right side belongs to the left eye, and the image seen to the left belongs to the right eye, it is *crossed diplopia*. This is represented in Fig. 3738, and occurs in divergent squint. To determine

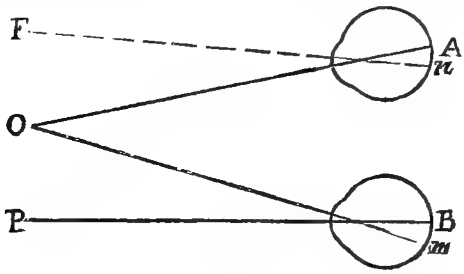

FIG. 3738.

which image belongs to the right eye, and which to the left, cover one eye and the image belonging to it will instantly disappear. Another method of identifying the images is to place before one eye a piece of colored glass, when the image belonging to that eye will instantly appear colored. In making these tests for diplopia a candle or lamp flame is an excellent object to have the patient look at.

Objective Symptoms.—If the squint be well marked, inspection, sometimes the most casual, will reveal the defect, and show which eye it is that deviates. But even in what may seem to be an unmistakable case there is a possibility of error. We judge of the direction of the visual axis by the direction of the centre of the cornea; and usually the visual axis pierces the cornea near its centre, or a very little to the nasal side of the centre. But sometimes the visual axis deviates considerably from its usual direction, so that, when it is properly directed toward the object fixed, the centre of the cornea will be turned considerably to one side, and the eye will appear to squint. Or the centre of the cornea will be turned apparently in the right direction, and the visual axis will really deviate considerably from the object looked at.

To determine whether the eye really does squint, direct the patient to gaze steadily at a certain object in front of him, and cover first one eye and then the other. If both eyes are properly directed toward the object, there will be no change of position when either one is covered. If one eye have its visual axis turned elsewhere, covering it will not cause any change of position; but covering the eye which has been really directed toward the object will cause the eyes or head to be turned, so that the eye which had looked elsewhere may now fix on the object. If, however, both eyes have been fixed on the object, but only by an undue effort, the covered eye will deviate and take such position as can be preserved without the undue effort. The objective test of covering the eyes alternately while fixed upon some point and watching their behavior should be repeated until the observer is satisfied as to the presence or absence of squint. Having ascertained that squint is actually present, the first point to be settled is whether it is *concomitant* or *paralytic*.

CONCOMITANT STRABISMUS is a wrong, and usually variable, co-ordination of the movements of the eyes with reference to each other, without marked limitation of these movements in any particular direction. In general, it is to be noticed whatever the direction of the object looked at, but its amount may vary from time to time, and is often greater the nearer the object is to the eye. It commonly appears in early childhood, but may exist from birth, and more rarely begins during adult life.

Convergent squint is the most common form of concomitant strabismus. In it the visual axes, instead of converging to the point looked at, converge to and cross at a point nearer the eye, as in Fig. 3737. In it the diplopia is homonymous, and on covering the eye which is fixed on the object it turns in toward the nose, while the other turns from the nose and fixes the object.

Divergent squint comes next to the convergent in frequency. In this form the visual axes do not converge enough, either meeting at some point beyond the object looked at, or remaining parallel or even divergent; the diplopia is crossed, and when the fixing eye is covered it turns out toward the temple, diverges, and the other eye turns toward the nose and fixes the object. When the visual axes remain always divergent, no matter how great an effort is made to turn them in, the squint is said to be *absolutely divergent*. When the visual axes can be made to converge, but not to converge enough for the visual axes both to pass through the point looked at, as in Fig. 3738, the squint is said to be *relatively divergent*. *Parallel squint* is the name formerly applied to those cases of relative divergence in which the visual axes remain parallel when they should converge toward a near object.

Vertical squint, in which one visual axis is directed more upward or more downward than the other, is exceedingly rare, except as complicating one of the other forms of concomitant squint. It is quite common in divergent squint to find the eye which habitually deviates to be turned upward, as well as outward; and, as this condition is frequently associated with drooping of the upper lid, it has been regarded as an effort of nature to exclude the deviating eye from vision and thus avoid diplopia.

Constant squint, as its name implies, is always present, the visual axes never assuming normal relations. Opposed to it is *periodic* or *intermittent squint*, which is only present part of the time, the relations of the visual axes being at other times entirely normal. The periodicity may be looked upon as being an exaggeration of those variations in degree which constant squint usually presents; and it is irregular, not cyclical, unless dependent on some cyclical variation in the general nervous system, like that which attends menstruation.

Periodic squint is apt to be most marked when the general tone of the nervous system is low, or at times of great excitement, or when the eyes are particularly taxed; a form of convergent squint, appearing only during strong effort of the accommodation, being called *accommodative squint*. Squint occurring during violent disorder of the general nervous system would not be spoken of as periodic, but as *convulsive squint*. Closely allied to periodic and convulsive, perhaps standing rather between them, is *hysterical squint*.

Monolateral or *monocular squint* is the form in which it is always the same eye that fixes on the object looked at, while the other eye always deviates. If the fixing eye be covered it will deviate, while the ordinarily deviating eye fixes; but, upon uncovering, the deviation is soon transferred back to the eye which habitually presents it. The large majority of cases of concomitant strabismus are in this sense monolateral. But it must not be supposed that only the deviating eye is at fault. The squint is a faulty co-ordination of the motions of the two eyes, and the reason that it is always one eye that deviates is simply that the fixing eye has better vision, or is more easily used, as in hyperopia of differing degrees the use of the eye with the lower degree entails less exertion of the power of accommodation.

Alternating squint is the variety in which the deviation is sometimes presented by one eye, and sometimes by the other; either of them becoming the fixing eye when the other is covered, and continuing to fix after the other is again allowed to participate in the act of vision. Cases which are frequently at their outset, to some extent, alternating, may after a time become quite monolateral. Such cases, however, show from the start a disposition

to let one eye deviate more than the other; and true alternating strabismus may exist many years without tending to become monolateral, the determining factor being the equality or inequality of the two eyes as to acuteness of vision and ease with which they can be used.

Absence of Binocular Fusion.—In speaking of diplopia we have already given the conditions necessary for its production; and since, in the large majority of cases of concomitant squint, some of these conditions are lacking, most persons with squint do not experience double vision. In some cases it is quite obvious why there is no diplopia, as where corneal opacity, or a high degree of ametropia, prevents the formation of a retinal image in the deviating eye. In another class of cases the reason is less obvious, yet not hard to understand; as where, although the deviating eye presents no abnormal appearance either to external inspection or with the ophthalmoscope, when the ametropia is not excessive, yet the acuteness of vision is very low. Here amblyopia, probably indicating some defect of development, prevents the deviating eye from any considerable participation in the act of seeing. But there is still another class of cases in which, although each eye, when tested alone, shows good power of vision, and in which there can be no doubt that both eyes are usefully employed by their possessor, yet with marked squint there is no diplopia.

This state of affairs must be looked upon as a reversion to a type of visual act, common to most of the lower animals, in which, though they have two eyes, nothing like our binocular vision can be assumed to exist; the power of what has been called binocular fusion is lacking. It is quite conceivable that this power may now and then be lacking as a congenital anomaly; it may perhaps be always lacking at birth, and in all cases be a matter of individual development. Certainly it varies greatly in extent of development among those who undoubtedly possess it. The power is most developed and longest retained with reference to images formed on the macula lutea, if, indeed, it be not wholly confined to these. One who lacks entirely this power cannot have binocular diplopia, and cannot judge any better of the distance of unfamiliar objects with both eyes open than when one is shut.

Amblyopia with Squint.—Allusion has already been made to the large number of cases of squint in which there is great defect of vision, without any gross change to account for it. This amblyopia was formerly known as *amblyopia ex anopsia*, or amblyopia from disuse. It was supposed that squinting eyes presenting no lesion sufficient to account for their amblyopia had originally possessed good vision, that when they began to squint it caused diplopia, that to avoid diplopia the image formed in the deviating eye was actively "suppressed," excluded in some way from producing its proper effect on consciousness; and, further, it was supposed that this "suppression" or "exclusion" reacted injuriously on the sensibility of the eye subjected to it, causing a permanent amblyopia. For a time the frequent occurrence of this special form of amblyopia from disuse was scarcely questioned; but recently this series of suppositions has been challenged by various observers, most actively by Schweigger; and they have been shown to have no sufficient foundation in the facts. There is nothing to show that in many of these cases diplopia has ever existed. Where diplopia does exist in the beginning of a squint, it may disappear with the loss of binocular fusion, without the least impairment of visual acuteness; and in cases of paralytic squint, which are often seen from the beginning, and which sometimes become quite constant and are apt to be attended with very annoying diplopia, such a process as that supposed to lead to *amblyopia ex anopsia* is quite unknown.

Causes of Concomitant Squint.—The highly specialized character of the movements designed to secure binocular vision makes it extremely probable that they depend for their perfection on individual development. The controlling influence in such development is binocular fusion. Under the head of latent squint, we shall see how many cases of squint are kept from consummation by the desire to avoid diplopia, and it is in every way probable that a much larger number of cases are, during the early years of life, by this same impulse, led to so use the muscles which move the eyeball as to secure their symmetrical development and so do away with any tendency to squint. When, therefore, binocular fusion is impossible, or the tendency to it unusually feeble, as where the vision of one or both eyes is very imperfect, or where the faculty of fusion itself is not added to good vision of each eye alone, the orbital muscles never attain that normal development which enables them, by their elastic tension, to keep the visual axes properly directed to the point looked at. And while the rudiments of the proper binocular movements exist, so that both eyes may turn upward or downward, or to either side, at the same time, or converge somewhat more for near seeing, or somewhat less when a distant point is fixed, the perfection of their co-ordination, bringing the visual axes always to intersect at the point fixed, is not attained, and concomitant strabismus results. Of course, under this view anything which impairs the development of the visual centres or the acuteness of vision—as hereditary anomalies, convulsions, prolonged nutritive disorders, injury of the eyeball, keratitis, or high ametropia—becomes a cause of squint. But ametropia has an especial share in the causation of squint, as was first pointed out by Donders, although the importance of this factor has often been much exaggerated. Normally, the exertion of the power of accommodation is accompanied by convergence of the visual axes; the full power of the accommodation cannot be exerted without strong convergence. Hence in hyperopia, where the accommodation must be exerted more strongly to focus the image of the point looked at upon the retina, it is reasonable to expect a special tendency of the visual axes to converge more than in emmetropia, where the accommodation is less taxed. Statistics show that convergent strabismus usually occurs in hyperopic eyes. Still, as a large majority of all eyes present a low degree of hyperopia, it cannot be regarded as proved that the association of low hyperopia and squint is, in many cases, more than accidental. In the higher degrees of hyperopia, the proportion of patients presenting at least a periodic squint is too great to be accounted for in this way; and the view that hyperopia is, in some cases, one cause of squint, is fully supported by the results of treatment directed to the prevention of excessive effort of accommodation.

In myopia not only is it possible that the need for complete relaxation of the accommodation, even when a near object is looked at, may lead to deficient convergence of the visual axes, or divergent squint, but there is also an anatomical obstacle to normal binocular movements, in the shape of the myopic eyeball. The posterior segment of the emmetropic eye is spherical, and it rests in a spherical socket of orbital fat and connective tissue which it fits accurately, no matter in what direction the eye is turned. And in cases of hyperopia, even of the higher degrees, that are commonly met with, the deviation from the spherical form is comparatively slight. But in myopia, which runs into higher degrees than hyperopia, and of which the higher degrees are more common, there is an antero-posterior elongation of the globe which is often very marked. This makes the eyeball an oval, fitting in an oval socket, in which it cannot be turned without changing the shape or direction of the socket, by actual displacement of the orbital tissue. Hence convergence of the myopic eye requires excessive effort, while myopia, restricting the range of distinct vision, requires that the convergence should be especially great. Often, and in the highest degrees of myopia always, the effort at convergence is abandoned, and a divergent strabismus permitted. This is at first relative and periodic, but, if associated with deficiencies of muscular development, is very likely to become in time absolute and constant.

Treatment of Concomitant Squint.—The preventive treatment would include all measures favoring the normal development of the general nervous and muscular systems, or calculated to improve the acuteness of vision. Both to influence the acuteness of vision, and to give

the normal accommodation and range of distinct vision, *errors of refraction are to be corrected.* In convergent squint with hyperopia, the convex lens fully correcting the latter should be worn constantly. If the squint is commencing in a child too young to wear glasses, it is advisable to place the eyes under the influence of a *mydriatic*, as

Atropine sulphate	gr. j.
Distilled water	℥ ij.

one drop to be placed in each eye three times a day. This should be kept up for some time after the squint has disappeared, or, when squint continues, at least for some weeks, until it is clearly demonstrated that the deviation is not being favorably influenced by it.

The mydriatic acts by paralyzing the accommodation, and so preventing any attempt to use it which may bring about excess of convergence. This remedy is worth trying in any case of commencing convergent squint, whether associated with hyperopia or not. Care must be taken that the solution used is strong enough, and is efficiently applied; for if only enough of the mydriatic is instilled to somewhat weaken the accommodation, the effect will be not to prevent, but to increase the accommodative effort, and therefore the accompanying convergence.

In myopia concave lenses, either correcting all of it or so much as is necessary to enable the patient to see clearly at a distance of some twelve inches, may be used to prevent divergent squint. Or if the squint is already established, the use of correcting lenses, by making accommodation necessary for near vision, may bring about some convergence.

As aiding in the proper development of the muscles concerned, what are called *orthoptic* or *orthopædic exercises* are recommended. They consist usually in looking through some form of stereoscope at lines, letters, or figures, a part of each being seen by one eye, and the remainder being presented to the other eye; by an effort these are to be fused into one harmonious whole. An ingenious attempt in the same direction, proposed by Cuignet, is made by attaching to a firm head-band an arm projecting horizontally from the centre of the brow, from which are suspended the page to be looked at and a ruler placed vertically between the page and the eye. The ruler cuts off a part of the page from each eye, but by using both eyes all parts may be seen; and the reading of each line necessitates the alternate use of both eyes. Orthoptic exercises are mainly of use to cultivate the faculty of binocular fusion where that exists, but is deficient in comparison with the obstacles it has to overcome.

As a palliative of concomitant squint, prisms may be worn in rare instances. They are so used as to cause the rays to enter the squinting eye in the direction of its visual axis and thus avoid diplopia, while the squint remains unchanged. Or they may be used as a sort of orthoptic apparatus, to bring the rays so nearly in the direction of the visual axis of the deviating eye that, by a little additional effort, the visual axis will be brought to coincide with their direction, and the squint thus lessened. In either case the strength of prismatic effect required is to be determined by trial, and this secured by placing prisms of equal strength before both eyes, with the refracting angle or thin edge of the prism in the direction in which the eyes deviate. Thus, in a case of divergent strabismus a prism will be placed before each eye, with its edge toward the temple; in convergent strabismus, with its edge to the nose; or, if the right eye turns upward more than the left, a prism with the edge up before the right eye, or with the edge down before the left, will give relief. Because of the weight of strong prisms, the dispersion of light which they cause, and the apparent distortion of objects seen through them, it is scarcely practicable to wear prisms of more than from four to six degrees; and for this reason they are rarely useful in cases of actual squint.

Since in the vast majority of cases of squint it is impossible to so develop the muscles concerned that they shall, by their elastic tension and normal contraction, keep the visual axes in proper relation one to the other, recourse is had to *operative measures;* these are intended so to change the connection of these muscles to the eyeball that the visual axes may assume approximately their proper positions. These measures are two in number: One of them is the severing of the tendon of the muscle toward which the cornea is turned, allowing it to retract and the eyeball to be turned toward the proper position by its opponent, so that it shall attach itself farther back upon the sclerotic, and thenceforth have relatively less power to turn the eye in its direction; this is called *tenotomy of the rectus,* or *strabotomy.* The other is *advancement of the tendon* of the muscle which has exerted too little influence on the direction of the eye, allowing it to acquire a new insertion closer to the cornea, and so exert a relatively greater influence in determining the direction of the visual axis. Since operative procedure is only to be resorted to where development cannot be expected to accomplish the relief of the deformity, it should not be tried until development is so far advanced as to leave it clearly indicated. Thus, it should not be done before the age of six or eight years in the highest degrees of squint, until after puberty for moderate amounts, and for low degrees not until adult life is approached or reached. Again, it is wise, before operating for squint, to determine the refraction of the eyes and try the effect of correcting lenses upon the deviation, or, at least in the convergent form, to ascertain what effect is produced by the use of a mydriatic. Neglect of wise caution in this direction is responsible for the not rare conversion of convergent into divergent squint. It is not rare for squint to occur, sometimes to persist for months or even years, and then to spontaneously disappear; and the premature correction of such a case by operation, though perhaps quite satisfactory at the time, may in the end bring both operator and operation into discredit.

In determining the operation to be done the amount of deviation is to be considered. This may be measured in degrees on the arc of a perimeter, by placing the deviating eye at the centre of the arc, making the visual axis of the fixing eye parallel to the axis of the instrument, and noting the number of degrees from the axis of the perimeter to the visual axis of the deviating eye. Or, if convergent, the number of metre-angles of squint may be found by placing at the root of the nose a metre-measure graduated to metre-angles (the same as dioptric focal lengths), directing the fixing eye to the other end of the stick, and subtracting one from the number of metre-angles indicated for the point at which the visual axis of the deviating eye crosses the measure. Or the deviation can be measured by placing a scale along the edge of the lower lid of the squinting eye, covering the good eye so that the other may fix, and then uncovering it and watching the deviation. Where the deviation is slight it is usually to be corrected by a tenotomy; where the deviation is much greater than can be remedied by a single tenotomy, it is generally best to do an advancement; and, if this proves insufficient, a subsequent tenotomy may be resorted to. As a rule, the inward deviation that can be remedied by a tenotomy of the internal rectus is greater than the outward deviation that can be overcome by a tenotomy of the external rectus; and the effect of the former operation tends to increase for a certain time after its performance, while the effect of the latter rather tends to diminish.

To perform *tenotomy* of one of the recti muscles it is better to have an assistant, although the operation can be done without aid by using a spring-stop speculum to keep the eye open. The instruments required are a pair of scissors with fine but slightly blunt points, a pair of strabismus forceps (a form of fixation forceps with narrow toothed jaws), a strabismus hook, and a lid-elevator or speculum. A drop of a four per cent. solution of cocaine is to be placed over the insertion of the tendon to be cut. This is repeated every two minutes for five or ten minutes. The lid-elevator or retractor is then introduced beneath the upper lid and confided to the assistant, who stands behind the patient, steadying the head against his own

breast. The operator then seats himself on the same side of the patient as the eye to be operated on, and, with the forceps in one hand, seizes a fold of the conjunctiva some five mm. back from the margin of the cornea, and over the lower part of the tendon to be divided. With the scissors in the other hand, this fold in the conjunctiva is snipped so as to make an opening which, when stretched out, will be from five to eight mm. in length. The forceps are then allowed to drop the conjunctiva, and are introduced through the cut just completed and made to grasp the subconjunctival tissue. This is also divided with the scissors, and while it is still held by the forceps the points of the scissors are to be introduced beneath it, and, being alternately spread and brought together as they are pushed forward, are made to divide the tissue, until a free opening is obtained for the introduction of the hook. The scissors are then laid down and the hook is introduced, care being taken to keep the point in contact with the sclerotic, and is pushed back and then upward under the upper part of the tendon, which is drawn forward. The forceps are now removed and the hook depended upon to fix the eyeball. The points of the scissors are introduced beneath the conjunctiva, one point close to the hook beneath the tendon and close to its insertion, the other over the tendon and immediately beneath the conjunctiva. The blades being brought together, the tendon is divided and the hook can be pushed forward without hinderance to the margin of the cornea. The point of the hook is then turned downward, and the lower part of the tendon taken up and divided in a similar manner. When no bands remain to prevent the hook from freely slipping forward to the corneal margin, it is removed and the motility of the eye is tested. If motion is not decidedly limited in the direction of the cut tendon, the hook is to be introduced again and other bands searched for, especially at the upper and lower margins of the tendon, and these must all be divided, or no material effect will be produced by the operation. In this connection it is to be remembered that the width of the tendon to be divided is from six to ten mm. The effect of the operation can be considerably enhanced by freely dividing the subconjunctival tissue around the tendon.

For *advancement of the tendon* of one of the recti muscles, there are required, in addition to the instruments used for tenotomy, fine needles and silk sutures, and a needle-holder. It is better to have the patient recumbent, and, after the use of cocaine, the introduction of the elevator or speculum, and the tenotomy of the opposing muscle, an incision is made with the scissors in the conjunctiva, parallel to the corneal margin, five mm. from it, and extending the whole width of the tendon to be advanced, and some distance beyond it on either side. The tendon is now to be isolated and raised on the hook. A needle armed with the silk should then be passed through each margin of the tendon from without inward, some distance back from its insertion; and, having been drawn through, is to be introduced beneath the conjunctiva near the corresponding margin of the insertion, carried around the cornea, and brought out near the extremity of its vertical diameter, thus including a good mass of tissue. The ends of each suture are now tied together and the sutures drawn out of the way. The tendon is then severed at its insertion, and a small piece of it may be cut off if a decided change of the direction of the eyeball is desired. A third suture, connecting the centre of the tendon with the corresponding pericorneal tissue, is now introduced, and the sutures are tightened, care being taken that the upper and lower margins shall be equally drawn upon. The eye is then closed and bandaged. The stitches are allowed to remain several days, unless it is feared that too great an effect will be produced.

In a large proportion of cases, the *result* of operative interference is only an approximate correction of the deformity, which may sometimes be improved by the subsequent use of glasses, or orthoptic training. Only where good binocular fusion can be obtained may a perfect result be hoped for.

PARALYTIC SQUINT is a lagging behind of one eye when the patient attempts to look in a certain direction; it is due to limitation of the movement of the eye, by partial or complete loss of power in the muscle or muscles which should turn the eye in that direction.

Such palsies, like those of other muscles, may arise from lesions of the muscle itself, of the centres governing its action, or of the connecting nerve-tracts; usually they have the latter origin. Early, in a case of uncomplicated paralytic squint, all ocular movements which do not depend on the muscle or muscles affected may be perfectly normal; and, so long as no demand is made on these muscles, no diplopia or inconvenience results. But when it is attempted to turn the eyes in some direction where the action of the affected muscle will be essential, it is found that, while one eye responds normally to the impulse of the will, the other responds imperfectly or not at all; and the farther in this direction the sound eye is carried, the greater the deviation of the affected eye, and the wider the separation of the two images, which in this kind of squint are almost always present. Hence the squint and diplopia are not constant, but only appear when the eyes are turned in a certain direction—which sharply separates this from concomitant strabismus. In periodic concomitant squint the squint is sometimes absent, but when present it is so irrespective of the direction of the object fixed; in paralytic strabismus the squint, though sometimes absent, is always present when the eyes are turned in a certain direction, and always absent when they are turned in another. After paralysis of one of the muscles has existed for some time, its nutrition is impaired and elastic tension reduced, so that it is no longer sufficient to balance the elastic tension of its opponent. The latter turns the eye toward itself, so that it cannot assume the normal position, even when the muscles are relaxed as much as possible. When this occurs the deviation becomes more or less constant, and if some power of voluntary contraction be recovered by the paralyzed muscle, after its elastic tension has become thus impaired, the case assumes somewhat the character of a concomitant strabismus. The form of the squint depends on the muscle or muscles involved. It is, for practical purposes, convenient to classify paralytic strabismus by the nervous supply of the muscles involved.

Paralysis of the abducens nerve, or *external rectus muscle,* causes a most frequent and simple form of paralytic squint. The distribution of this nerve (the sixth cranial) being confined to the one muscle, and the action of this muscle being essential only to turning the eye outward (toward the temple), especially outward and upward (since the superior oblique has some power of turning it outward and downward), diplopia and deviation are only noticed when the patient tries to look toward the side on which the affected muscle is situated. If the paralysis be complete, diplopia begins as soon as the object fixed passes the median line; if it be but partial, it may not appear until the eyes have been directed somewhat toward the affected side. When the case has lasted some time, so that the internal rectus has acquired an elastic preponderance, the deviation and diplopia involve a greater part of the field of vision; but, in any case, the deviation and the separation of the double images are least when the eyes are directed most toward the sound side, and greatest when they are directed most toward the affected side. Congenital paralysis of both of the abducens nerves, causing a constant convergent squint with inability to turn the eyes to either side, without diplopia, and perhaps with excentric fixation, has been occasionally observed.

Paralysis of the Patheticus, Fourth Nerve; the Superior Oblique Muscle.—Here again we have a nerve supplying a single muscle, but one whose action is somewhat complex. Its function is to aid in turning the eye down and out, and to rotate it about the antero-posterior axis. The deviation and diplopia appear mainly when the eyes are turned toward the affected side and rather downward; when the eye is turned to the affected side the false image appears so inclined that its upper end is close to the upper end of the true image, while the lower deviates more widely from it.

Oculo-motor Paralysis.—The oculo-motor, or third nerve, which is distributed to three of the recti muscles—the inferior oblique, the elevator of the lid, and the iris and ciliary muscle—may be paralyzed in one or more of its branches. With the paralysis of its intra-ocular portion, causing loss of accommodation and some dilatation of the pupil, we are not here concerned. The involvement of all the extra-ocular branches causes drooping of the lid (ptosis), and leaves the eye unable to move in any direction except outward and a little downward, under the influence of the external rectus and superior oblique muscles. On attempting to look toward the sound side, or upward or far downward, deviation and diplopia appear, and increase *pari passu* with the effort to turn the visual axes in either of these directions. The same thing occurs when any attempt is made to converge for a near object. According to the movements attempted does the squint assume more the character of a divergent or a vertical strabismus.

When the sound eye is excluded from vision there is experienced a great uncertainty as to the position of objects, which amounts to a kind of vertigo. If the palsy has lasted more than a few days, a permanent outward deviation of the visual axis is usually established. Oculo-motor palsy may involve only a part of the muscles supplied by the nerve, or may even be limited to a single one. Almost always it affects some more severely than others ; and quite often, when all have been severely involved, some will recover almost completely, while others show little or no improvement. Hence, individual cases vary greatly as to the nature of the deviation and diplopia ; and each must be studied by the light of the general principles governing the occurrence of squint ; deviation occurs when the eye is turned toward the weakened muscle, and the false image is apparently displaced in the same direction. Several cases have been reported of oculo-motor paralysis recurring at considerable intervals, and tending to become fixed and associated with other cerebral symptoms ; the essential character of these paralyses is still unknown.

Ophthalmoplegia externa is the term applied to a paralysis of all the muscles attached to the eyeball.

Treatment of Paralytic Squint.—If the paralysis be due to some lesion, the location and nature of which are otherwise obvious, as a tumor, or is the result of some traumatism of the orbit, dependence is to be placed on the rational surgical treatment of the cause. Where, however, the palsy is the most definite or only symptom perceived, recourse must be had to internal or general medication. The largest number of these palsies come from some syphilitic new-growth, involving the sheath of the nerve or adjoining structures, or from syphilitic disease of the nerve itself. A few come from rheumatic disease in the course of the nerve-trunk, and a considerable number arise from a focus of disease in cerebro-spinal or spinal sclerosis. If there be a clear history of rheumatism, or collateral evidence of the rheumatic nature of the attack, anti-rheumatic remedies should be carefully tried. If there is other evidence of commencing or progressing sclerosis, we may assume this to be a manifestation of the general tendency in that direction. But in all other cases it is probably best to assume that the lesion is syphilitic, and to treat it with increasing doses of potassium iodide. A good way is to prescribe

Potassium iodide.................... ℥ j.
Water.............................. f ℥ j.,

each drop of which will contain about a grain of the drug. Let this be taken in water or milk, commencing with ten drops, three times a day. On the third day begin giving the same dose four times daily ; and after that, on each alternate day increase the dose by five drops ; and so continue until there is evidence of increase of power in the paralyzed muscles, or until symptoms of iodism appear. If decided improvement begins we may simply continue the administration of the drug without further increase of the dose, and if iodism occurs the drug must be suspended, or its dose considerably diminished.

In cases seen within a few days of the commencement this treatment generally secures great improvement, and not rarely complete recovery. But if many weeks or months have elapsed, there is not so much to be hoped from it. In very many cases, medical treatment leaves the cure far from complete, and certain local measures are to be resorted to.

It is scarcely practicable, on account of their situation, to pass through the affected muscles electric currents powerful enough to have much effect on them, without endangering the optic nerve and retina.

Prisms and tenotomy are not generally of any use, because the extent of the deviation varies with the direction in which it is desired to turn the eye. Where the paralysis remains absolute and the resulting deformity is very great, cosmetic improvement may sometimes be obtained by making an advancement of the tendon of the paralyzed muscle and the neighboring portion of the capsule of Tenon, with a tenotomy of the opponent muscle. The immediate effect, obtained in this way, should always be a decided deviation toward the paralyzed muscle, as the healthy opponent will, after a time, be sure to greatly lessen this effect. In cases of non-recovery or incomplete recovery from these palsies, passive motion, as proposed by Michel, has been used with apparent benefit to a considerable proportion of the cases subjected to it. Cocaine having been applied to the eye, the insertion of the paralyzed muscle is seized with the fixation forceps and the eyeball dragged back and forth in the direction in which the muscle would act, so that the muscle is alternately stretched and relaxed to its utmost ; and this is continued for about two minutes. This manipulation is to be repeated every two or three days ; but if no improvement is noticed after a few repetitions, none is to be hoped for from a further continuation of such treatment. When the cure of a case of paralytic squint is almost complete, orthoptic exercises may be of benefit.

Latent or Dynamic Squint.—A perfectly symmetrical development of the eye-muscles and their governing centres, which secures exactly the proper balance of elastic tension, contractile power, and motor impulse, that makes the co-ordination of binocular movements perfect, is perhaps as rare as is mathematically exact emmetropia. Binocular fusion is required to make up for its deficiency, in a very large proportion of cases, by inducing the slight extra, although involuntary, contraction of those muscles which without it fail to quite balance their opponents. In probably a large majority of persons the withdrawal of the influence of binocular fusion leaves a perceptible though slight squint. Such squint is called latent or dynamic, or is spoken of as an *insufficiency* of the weaker of the opposed muscles. It has also been proposed by Stevens to call it *heterophoria*, a tending of the visual axes toward different points. If not great, the latent deviation will cause no trouble to a person with a well-developed musculo-nervous system. But in persons of inferior muscular development and small reserve of nerve-force, even moderate degrees of insufficiency may give rise to the symptoms of eye-strain, especially if the eyes are required to do large amounts of work, or to work under unfavorable conditions.

Diagnosis of Latent Squint.—When, from the evidence of eye-strain, it is suspected that this form of strabismus is present, its existence is revealed by rendering impossible binocular fusion. For the objective test, binocular vision is rendered impossible by holding something opaque, as the hand, between one eye and the point fixed. The eye thus excluded will then, if there is the tendency to squint, be seen to deviate and take the position of equilibrium for the muscles that move it. Upon uncovering the eye, it quickly assumes again the position in which its visual axis will pass through the point fixed. In this way, by repeated trials and close watching of the eyes, quite low degrees of latent squint can be detected. But still more delicate is the subjective test. To make it, binocular fusion is prevented by placing before one eye a prism of about six degrees, with its base directly up. The eyes now being fixed upon some object, as a dot on a card across the room, this will appear doubled, the eye

with the prism before it seeing a false image below the true one. To make the test for a near point it is important to have the eyes accommodating for the point fixed, and to secure this the writer uses a single group of four fine crossed lines, like those shown in Fig. 3739, drawn on a plain card. If no tendency to squint be present, and the prism is held with its base directly up, the false image will be seen exactly under the true one, as represented in A, Fig. 3739; but if there be squint, the images will not be in the same vertical line, but in convergent squint will part from this position homonymously, and in divergent squint will be crossed. Thus, supposing the prism to be held with its base up before the right eye, the lower image will belong to the right eye, the upper to the left. An appearance like B, in Fig. 3739, will indicate convergent strabismus, the image of the right eye being to the right, and the image belonging to the left eye to the left. On the other hand, C, in the same figure, representing a tendency to crossed diplopia, indicates latent divergent squint. To determine the presence or absence of latent vertical squint, the most satisfactory test is the repeated trial of the power to "overcome" a prism with its base up, held first before one eye, then before the other. If any tendency to such deviation exists, it will be revealed by ability to overcome a prism with its base up before one eye, which cannot be overcome when the prism is placed in the same position before the other.

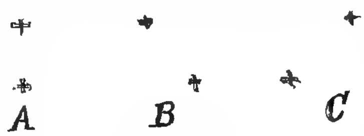

FIG. 3739.

Forms of Latent Squint.—Divergent squint, insufficiency of the internal recti muscles, or exophoria, is the most common. It was first described in connection with myopia, where it is particularly liable to cause trouble, on account of the need for unusually strong convergence; but it is even more frequent in persons who are hyperopic and use their eyes much, or under unfavorable conditions, for close work.

Convergent latent squint, insufficiency of the external recti, or esophoria, is frequently seen in hyperopes who tax their eyes. Vertical squint, insufficiency of the superior or inferior recti, or hyperphoria, is a very rare condition; but low degrees of it may cause much headache and nervous tension, because there is less power of compensatory extra contraction in the superior and inferior than in the lateral recti. A tendency to vertical deviation of more than from two to four degrees is too extensive a squint to be kept latent, and one even half as great may severely tax the reserve power of the muscles concerned.

Treatment.—All remedial measures spoken of in connection with other kinds of squint may be resorted to for this. On account of the lesser extent of the deviation prisms are particularly available. On the same account tenotomy and advancement require more accurate and delicate adjustment to the needs of the case, and are to be resorted to only after a thorough and rather prolonged acquaintance with those needs. But reduction of the amount of trying eye-work, and hygienic measures calculated to improve the condition of the nervous system generally, are of the utmost importance in the majority of such cases.

Mixed Forms of Squint.—While nearly all cases of strabismus are readily referred to one or the other of the foregoing classes, and while it is of the first importance to have clear conceptions as to the special characteristics of each class, it should not be forgotten that many cases present the peculiar features of more than one class. Thus we may have a dynamic divergent squint for distant vision running into an actual divergent squint for near work; or a case of well-marked concomitant squint with an overstretched muscle notably paretic; and allusion has already been made to the occurrence of concomitant in the later stages of paralytic squint. In strabismus, therefore, as elsewhere throughout the domain of medicine, each case is a subject for individual study, a most important kind of original investigation.

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Edward Jackson.

STRAMONIUM LEAVES AND SEED (*Stramonii Folia*, U. S. Ph., Br. Ph.; *Stramonii Semen*, U. S. Ph.; *Stramonii Semina*, Br. Ph.; *Folia Stramonii*, Ph. G.; *Stramoine ou Pomme épineuse*, Codex Med.; Jamestown Weed, Thorn-apple, Apple of Peru, Stinkweed, etc.). *Datura Stramonium* Linn.; Order, *Solanaceæ*.

FIG. 3740.—Flowering Branch of Datura Stramonium, with Fruit. (Baillon.)

This well-known weed is a coarse, smooth annual, from one to six feet high, with an upright tri- and dichotomously-branched stem, large ovate, coarsely dentate leaves, and long, bell-shaped flowers. The stem is stout, smooth, green (or reddish-brown, *D. Tatula*), more or less hollow; it branches at, say a foot from the ground, in three directions, and each of the divisions so formed soon forks repeatedly, the whole forming a spreading bushy head. Leaves alternate, lateral to the branches, petioled, ovate, pointed, irregularly and deeply dentate, with wavy margins. Flowers solitary, terminal, in the forks of the branches, short-peduncled. Calyx tubular, five-lobed, divisions pointed. Corolla funnel-shaped, three or four or more inches long, plicate and convolute in the bud. Border five-lobed, lobes pointed, pale pink, purple (in *D. Tatula*), or white. Stamens five, inserted in the tube of the corolla. Ovary two-, apparently four-celled; ovules

numerous. Fruit erect, ovoid, nearly as large as a hen's egg, covered with rigid sharp spines, opening part way down by four valves which curl back at the apex; seeds in four divisions, very numerous—"About one-sixth of an inch (4 millimetres) long, reniform, flattened, pitted, and wrinkled; testa dull brownish-black, hard, inclosing a cylindrical, curved embryo embedded in a whitish, oily albumen; of an unpleasant odor when bruised, and of an oily and bitter taste" (U. S. Ph.). The leaves, like those of belladonna, shrink very much in drying, and lose their peculiar nauseous odor. They are described as follows: "About six inches (15 centimetres) long, petiolate, smooth, ovate, pointed, unequal at the base, coarsely and sinuately toothed; after drying, thin, brittle, and nearly inodorous; taste unpleasant, bitter, and nauseous."

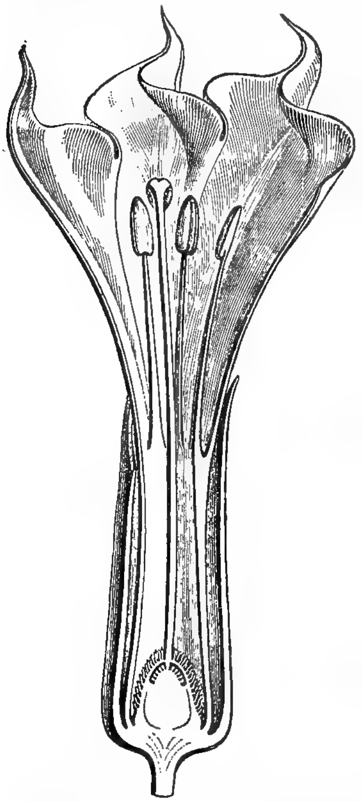
FIG. 3741.—Longitudinal Section of Flower of Datura Stramonium. (Baillon.)

The original home of Stramonium has been a puzzling question for botanists, apparently from the rapidity with which it spread over the earth in the sixteenth century. Tropical South America and the countries around the Caspian Sea are thought to be the most probable sources. It is more than possible that it is a native of both hemispheres. From whatever place it came, it has made itself at home everywhere over the warmer parts of the earth, taking most kindly to old rich gardens and corners, dunghills, and door-yards.

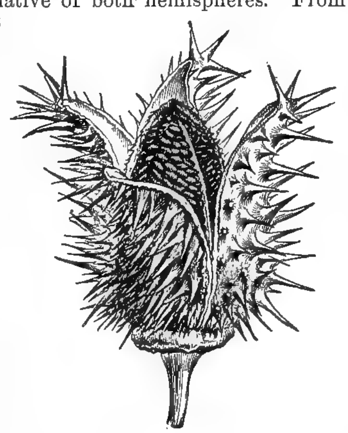
FIG. 3742.—Datura Stramonium; Ripe Fruit. (Baillon.)

COMPOSITION.—Stramonium contains the principal mydriatic alkaloids of the family: *atropine* and *hyoscyamine*—or at least the latter, and an amorphous alkaloid considered by Planta and others to be identical with the former, but either not fully proved to be so, or not yet prepared quite clean. *Daturine*, a name formerly given to the Stramonium alkaloids, is now said to be only hyoscyamine. The seeds contain about one-fourth of one per cent. of atropine, the leaves not more than one-third as much. Besides these the leaves contain a large amount of ash (14.5 per cent.), nitre, asparagin, and other unimportant substances.

ACTION AND USE.—From the above analysis it will be seen that Stramonium has scarcely any difference in action from Hyoscyamus, and but little from Belladonna. It is, indeed, capable of being used for exactly the same purposes, only it is more quieting and hypnotic than the latter, probably on account of its hyoscyamine. Custom, perhaps, as much as anything, has directed the leaves of this species, instead of those of the others named, to be used in the local antispasmodic treatment of asthma, for which purpose it is almost entirely prescribed. The common method is to administer it by smoking. The leaves may be burnt in a pipe or on the cover of a hot stove, or they may be made more inflammable by being soaked in a strong solution of saltpetre and dried, after which they will burn steadily, without flame and without requiring any apparatus; prepared in this way and flavored with aromatics and balsams, they are the foundation of most of the "asthma cigarettes" and "pastilles," which are often better products than extemporaneous preparations are apt to be. The French Codex gives directions for making cigarettes of stramonium, containing one gram each of leaves, without any admixture. For internal administration Stramonium may be considered the same as Hyoscyamus. The following preparations are officinal, all made from the seed, the leaves being only used for smoking (one or two grams): Extract (*Extractum Stramonii*), strength about $\frac{4}{1}$; Fluid Extract (*Extractum Stramonii Fluidum*), strength, $\frac{1}{1}$; Tincture (*Tinctura Stramonii*), strength, $\frac{1}{10}$; and the Ointment (*Unguentum Stramonii*), strength (of the extract), $\frac{1}{10}$. All these have similar properties and uses to the corresponding preparations of Hyoscyamus and Belladonna, but are more hypnotic than the latter. Dose of Fluid Extract about 0.2 c.c.

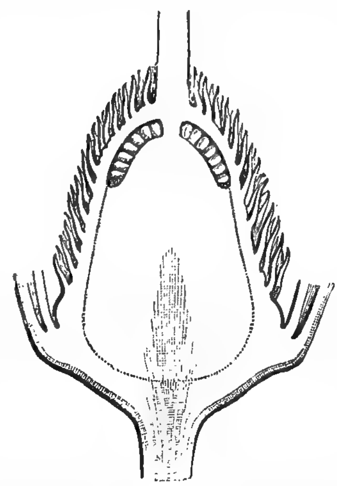
FIG. 3743.—Longitudinal Section of Ovary of Datura Stramonium. (Baillon.)

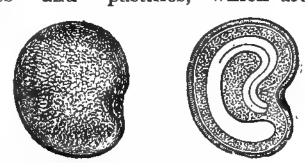
FIG. 3744.—Seed Entire and in Section, of Datura Stramonium.

ALLIED PLANTS.—*Datura*, of which the present plant is a characteristic species, consists of a dozen, mostly large, rank herbs, most of which have similar medical properties to the above. *D. Tatula*, with purple stems and flowers, is scarcely distinct from *D. Stramonium*. *D. alba*, of India, is used for the same purposes. One or two other species are cultivated for ornament. For the order, see BELLADONNA.

ALLIED DRUGS.—Belladonna, Hyoscyamus, Duboisia, Tobacco, etc. *W. P. Bolles.*

STRAWBERRIES (*Fraisier*, Codex Med., Rhizome, Fruit). *Fragaria vesca* Linn.; Order, *Rosaceæ*. The common garden Strawberry, like every other familiar plant, has been put to use as a medicine. Its leaves make by infusion a mild, rather pleasant, astringent tea, which is an occasional household prescription. With a little aromatic, like vanilla or ginger, a pleasant drink for those who cannot drink ordinary tea may be made.

Strawberry root, the rhizome and rootlets, dried, containing tannin, a little resin, etc., is an astringent and tonic of no great value, but is now and then employed as a domestic medicine.

Strawberries themselves have no medical properties, but the syrup made from them is an agreeable flavor for "siphon soda," and is frequently used by the sick for that purpose.

ALLIED PLANTS, ETC.—See ROSES. *W. P. Bolles.*

STRIBLING SPRINGS. *Location and Post-office,* Stribling Springs, Augusta County, Va.

ACCESS.—By the Chesapeake & Ohio Railway to Staunton, thence by stage thirteen miles to the Springs.

ANALYSIS (W. K. Tuttle, M.D.).—One pint contains:

	No. 1.	No. 2.	No. 3.
	Grain.	Grains.	Grain.
Carbonate of potassa	0.044	0.093	0.095
Carbonate of soda	0.095	0.780	0.123
Carbonate of magnesia	0.122	0.251	0.138
Carbonate of iron	0.009	0.016	0.014
Carbonate of lime	0.188	1.204	0.104
Sulphate of lime	0.028	0.156	0.386
Silicic acid	0.165	0.080	0.114
Chloride of sodium	.....	0.080	.....
Total	0.651	2.660	0.974
Gas.	Cub. in.	Cub. in.	Cub. in.
Carbonic acid	3	1.30	2
Sulphuretted hydrogen		0.03	..

	No. 4.	No. 5.	No. 6.
	Grains.	Grains.	Grains.
Sulphate of potassa	0.067	0.113	0.126
Sulphate of soda	0.083	0.293	0.224
Sulphate of magnesia	0.066	0.043	0.822
Sulphate of alumina	2.086	2.244	4.801
Sulphate of iron	1.192	1.643	1.615
Sulphate of lime	1.832	2.118	2.389
Sulphuric acid (free)	0.631	1.227	0.817
Silicic acid	0.244	0.264	0.264
Organic matter	0.469	.....	.....
Total	6.670	7.945	11.068

Springs Nos. 1 and 3 are chalybeate, No. 2 sulphur, and Nos. 4, 5, and 6 alum.

THERAPEUTIC PROPERTIES.—The variety and excellence of these waters render this a favorite resort. The alum springs are curative in chronic diarrhœa and catarrhs generally; the chalybeate are mild and efficient; and the sulphur is often needed to meet certain indications for which the others are not adapted.

These springs, sometimes called the Augusta, are located in the mountains of Eastern Virginia, and have long been popular, not only on account of the waters, but also for their beautiful and salubrious situation.

G. B. F.

STROPHANTHUS (Kombé, Arrow Poison, Inée, Onaye, etc.). The pods and seeds of several species of *Strophanthus;* Order, *Apocynaceæ.* This is a singular genus of tropical plants, mostly climbing shrubs. They are usually villous or hairy, although sometimes smooth, opposite-leaved plants with milky or colored bitter latex, terminal cymes of regular flowers, and very long fruits. Calyx five-pointed, glandular on the inside. Corolla funnel- or bell-shaped, gamosepalous, five-lobed, with ten scales or appendages; lobes pointed, in most species prolonged into long filiform or linear processes, six or eight times as long as the rest of the flower; these processes, whether erect, spreading, or, as sometimes is the case, straggling and drooping, serve at once to distinguish the genus. Anthers five, short, included in the corolla, upon which they are inserted by very short filaments. Pistil of two carpels, surmounted by one style and stigma. Ovules numerous. Fruit consists of two separate, diverging follicles, from ten to thirty centimetres long; they are fusiform, pointed, dehiscent; seeds numerous, from one-half to two centimetres long, silky or woolly, prolonged at the apex to a long, slender bristle, or awn, from five to twenty cm. long, which along its upper third, half, or more, becomes a plumose cylindrical brush. The genus comprises, according to Bentham and Hooker, eighteen species, all but one tropical, and growing in equatorial Africa, Southern Asia, or some of the Pacific islands; the extra-tropical species growing in Southern Africa. The Strophanthus seeds of commerce are probably the product of: 1, *S. hispidus* D. C., with hispid branches and leaves, and fine appressed tomentum upon the seeds; or of, 2, *S. Kombé* Oliver, a recently described species, perhaps scarcely distinct from the other, with coarsely hairy herbage and woolly seeds. Both these species inhabit Central and Western Equatorial Africa. There are, besides, several other species of the genus, with similar very bitter seeds, whose properties are probably similar to these, but so far they have not been tested.

DESCRIPTION.—Commercial Strophanthus pods are from twenty to thirty centimetres long, and two or three or more in breadth, slightly curved, longitudinally wrinkled, flattened, tapering to a fine point at the top. Color yellowish brown. They have a thin shell, finely grooved externally, and of a slightly brighter color inside.

The seeds are oval, flattened, tapering from near the base, about a centimetre long, four millimetres broad, and say two in thickness; a well-marked rib or keel on one side runs from the base to the apex; the awn is about ten centimetres long, plumed along the upper half with hairs whose length is three or four centimetres (the awn and their plumes are absent from the seeds as seen in the market). The surface of the seeds is densely silky, with shining hairs; it is grayish or greenish-brown, and is sometimes somewhat wrinkled lengthwise; section shows a whitish, oily kernel. The odor of Strophanthus seeds is bitter, and the taste (principally in the kernel) most intensely and disagreeably so. There are about two hundred seeds to each pod. All parts of the plant are bitter—seeds, pods, leaves, stems, and bark—but the seeds are by far the most so, and the most active, so that tinctures made of them alone, or of the entire pod, would differ much in strength. The hairs are inert.

HISTORY.—That certain tribes in the interior of Africa had efficient arrow poisons, and that some of these—inée, kombé, etc.,—were made in whole or partly from a paste made by grinding Strophanthus seeds, has been known for a number of years, and this poison was incidentally mentioned or examined by Pelikan, Hilton Fagge, and Stephenson in 1865, but the first serious investigation of its properties was published by Dr. Thomas P. Fraser in the "Proceedings of the Royal Society of Edinburgh," in 1870, who made an elaborate study of its action and chemistry, separating an active principle, of glucoside character in crystalline form, which he named strophanthin. (The strophanthin of the market at present is usually amorphous and rather deliquescent.) On account of the scarcity of the supply and other causes the investigations were not generally followed up, and for fifteen years the article was scarcely heard of, until 1885, when the same patient investigator read another important paper upon it before the British Medical Association, in which its utility as a medicine was shown by a series of cases and heart-tracings. Since this time it has been tried by numerous physicians in England and America, and so far, at least, with increasing reputation.

COMPOSITION.—The most abundant ingredient is a greenish fixed oil, of which about twenty-five per cent. can be obtained. This oil is slightly bitter, in consequence of the presence of a little of the bitter principle to be mentioned below, but is otherwise not remarkable or active. There is also a good deal of albuminous matter in the seeds, also inert. The active principle is *strophanthin,* a neutral glucoside, generally obtained as a light-colored, amorphous, moist powder, which is apt to deliquesce. As prepared by Mr. A. W. Gerrard (*Pharm. Journ. and Trans.,* May 14, 1887), it is "a pale-yellowish, amorphous substance, easily reduced to powder, but having some tendency to readhere. It is freely soluble in water and in alcohol, insoluble in pure ether and in pure chloroform; but if the latter liquids contain a trace of alcohol, a small portion of strophanthin is dissolved.

Strophanthin burns without a residue. It has well-marked glucocidal characters. He was unable to obtain it in crystals. One-fiftieth of a grain given to a dog proved fatal."[1] The crystalline strophanthin of Fraser does not appear as yet to be a commercial product. A crystalline substance can be obtained from the hairs of the seeds, called "*inein;*" it is not active. Gerrard's method of preparing strophanthin is as follows: An alcoholic extract of Strophanthus is dissolved in water, filtered, and precipitated with tannic acid. The precipitate is collected, washed with water, and while still moist mixed with an excess of basic acetate of lead. The mixture is dried, and exhausted with warm alcohol; the filtrate is treated with sulphuretted hydrogen, the sulphide of lead removed by filtering again, and the alcoholic solution evaporated to dryness. The residue (strophanthin) is dissolved in warm water, and then digested with animal charcoal, filtered, and evaporated.

ACTION AND USE.—Dr. Fraser, to whose extremely patient and scientific investigations we are indebted for the presentation of this new medicine, in his address before the section of Pharmacology and Therapeutics of the British Medical Society, 1885, says: "The pharmacological action of Strophanthus appears to be an extremely simple one. It may, I believe, be described in the few words that it is a muscle poison. However introduced into the body, it increases the contractile power of all striped muscles, and renders their contractions more complete and prolonged. In lethal doses it destroys, besides, the capacity of the muscle to assume the normal state of partial flaccidity, and causes the rigidity of contraction to become permanent and to pass into the rigor of death. As a result of the action on muscle, the heart is early and powerfully affected. It receives a larger quantity in a given time than any of the other muscles of the body, and therefore it probably is that Strophanthus affects its action more distinctly and powerfully than it does that of the other striped muscles. Indeed, by regulating the dose, a very distinct pharmacological influence may be produced upon the heart, while the other muscles remain apparently quite unaffected."

In order to ascertain the comparative effect of strophanthin and digitalin upon the heart muscle, Dr. Fraser exposed the separated heart of the frog to solutions of these substances. He found that "solutions of [Morson's ?] soluble digitalin of one part in a hundred thousand, of one in fifty thousand, of one in ten thousand, and of one in four thousand, each produced characteristic changes in the heart's action, but were not sufficiently strong to kill the heart, at any rate not within two hours. With strophanthin, on the other hand, a solution of one part in one hundred thousand quickly stopped the heart's action in extreme systole, characteristic changes in the heart's action having previously been produced. I then increased the dilution; and solutions of one part in two hundred and fifty thousand, of one in five hundred thousand, of one in a million, of one in two million, of one in three million, of one in four million and six hundred thousand, of one in six million, and of one in ten million, were each tried, with the result that the heart was characteristically affected, and killed by each of them. Even the almost inconceivably minute dose which was brought into contact with the heart, when a solution of one part of strophanthin in six million was used, produced complete stoppage of the heart's contractions in extreme systole in about twenty minutes." Its action upon the blood-vessels, on the other hand, was found to be less than one-tenth that of digitalis. Mr. Bahadhurji, who experimented with Strophanthus in co-operation with Dr. Langgaard in Berlin, found in frogs similar symptoms of heart-poisoning, with death in systole. Physiological doses reduced the number of beats to one-half, and made them more forcible; the heart filled well and emptied well. In rabbits very much the same thing was observed, the heart finally stopping in systole; the animal was sometimes convulsed before death. Strophanthus differs from digitalis in having a marked central effect upon the vagus. Blood-pressure tracings show no appreciable rise. Respirations at first increase, later are slower and weaker. Diuresis is not marked in healthy animals.

Dr. H. Hochaus, who experimented upon a number of persons, both well and suffering from several diseases, gives a careful résumé of the results in the *Deutsche medicinische Wochenschrift* of last year, of which the following is a synopsis, the doses for adults being from six to twelve drops of a five per cent. tincture of the seeds, say three times a day for several days, other circumstances of diet, etc., being the same:

In five cases of well persons, two showed no result, three increase of urine, two slowing of pulse.

In ten cases of valvular insufficiency, with soft, compressible, irregular pulse, and marked dyspnœa, two showed very great improvement, two moderate improvement, five no change. One improved remarkably, but died suddenly upon getting up. In some of the cases where Strophanthus failed digitalis was used with benefit.

In eighteen cases of enlarged, weak, myocarditic hearts, with diminished urine and weak irregular pulse, ten were more or less benefited and eight not improved; of the above ten who were benefited, six had been for several months in the hospital, and most of the different heart-strengthening medicines had been tried upon them. Digitalis acted best and quickest, next came Strophanthus.

In nineteen cases of nephritis, five of which were scarlatinous, one of these was much, one slightly benefited, three not at all. In one it produced diarrhœa. Of six cases of granular atrophy three were helped, and three were not. The remaining eight were cases of parenchymatous kidneys, with weak hearts, but little urine, and abundance of albumen. Of these three were improved in all respects, one in respiration only, and four not at all.

In two cases of pericarditis it did no good.

In two of chlorosis with functional palpitation it was beneficial.

From the above observations it will be seen that this drug is a very active one, that its effect upon the diseased heart is to strengthen its pulsations, and relieve numerous discomforts arising from its inefficiency, such as dyspnœa, palpitation, weakness, œdema, etc. It also in most of such cases increases the urine. It does not contract the vessels as digitalis does, and is said to be less likely to disturb the stomach; it is also not cumulative, the dose requiring to be increased after being used a while. On the other hand, it is claimed that it is less certain than the older remedy.

ADMINISTRATION.—The dose of Strophanthus cannot be considered as fully settled yet, but from one to six centigrams (from two-tenths to nine-tenths of a grain) of the seeds appears to be the usual range; it is not, however, given in substance, but usually as a tincture or a solution of strophanthin. No preparations are official, nor are they all uniform; therefore the physician should satisfy himself of their strength before using. Dr. Fraser's early tincture was about twelve per cent., which is stronger than is generally employed at present. His later recommendation is a five per cent. tincture, of which the dose is "from five to ten minims," and this strength is pretty commonly made now in this country. The directions for making are: "Strophanthus seeds, deprived of their comose appendages, reduced to powder, and dried, one ounce or part; ether, freed from spirit and from water, ten fluid ounces or ten fluid parts; rectified spirit, a sufficiency to obtain one (English) pint, or twenty fluid parts" (Fraser). The powder is carefully dried and exhausted of its fat by maceration and percolation with the ether, then redried and the tincture made in the usual way, by percolation with alcohol. Tincture of Strophanthus has a very pale straw color, and is intensely and nauseatingly bitter. The dose of strophanthin is variously stated at from .0003 to .001 gm. ($\frac{1}{200}$ grain to $\frac{1}{60}$.)

ALLIED PLANTS.—The common Oleander (*Nerium Oleander*) of the flower-garden is the nearest botanical relative at all familiar, the pods of the Oleander bear considerable resemblance to those of Strophanthus, and its

active principle, *oleandrin*, is also a heart poison. This may probably be said also of many plants in this poisonous order, see HEMP, CANADIAN, (*Apocynum Cannabinum*).

ALLIED DRUGS.—First, and most important of all, is Digitalis, which in its general usefulness probably exceeds Strophanthus, and to which the reader is referred (see FOXGLOVE); other heart "tonics" are Squills, Adonis, Lily of the Valley, and Antiaris.

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W. P. Bolles.

[1] Proceedings American Pharmaceutical Association, 1887, p. 355.

STRYCHNINE AND NUX VOMICA, POISONING BY.

Probably the earliest mention of nux vomica in medical literature is that by the younger Serapion, an Arabian, who wrote toward the end of the tenth century (Ed. Argentorati, 1531, clxiii., p. 115). The earlier European writers who treat of the drug recognize its poisonous qualities (Wepfer, "Cic. Aquat.," Bas., 1679, p. 194; Hoffmann, "Syst. Med.," 1728, t. i., § vii.–ix.). So much were the earlier physicians impressed with the dangers attending the use of nux vomica that, notwithstanding the evidence of Fallopius, Sennert, and others, of its medicinal virtues, and its adoption into the Pharmacopœias of London, 1651, and Amsterdam, 1636, the opinion of Hoffmann: "Inter medicamenta suspecta et quæ virus quoddam reconditum alunt, ut adeo plus damni, quam utilitatis aliis expectandum sit, merito nux vomica referri debet" (Ed. Genev., i., p. 226) was that generally entertained.

The earliest medico-legal reference to nux vomica is by Valentine ("Corpus Juris Med. Leg.," 1722, p. 219), who in 1680 was called upon to recognize the poisonous character of nuces vomicæ seized upon a prisoner.

The discovery of strychnine by Pelletier and Caventou, in 1818, provided the medical profession with a potent remedial agent, but, at the same time, placed a formidable weapon in the hands of the poisoner and the suicide. Several years elapsed, however, before either medicinal or criminal use was made of the newly discovered alkaloid, although numerous experiments made upon animals by its discoverers and others, shortly after its first isolation, made clearly manifest the powers of strychnine.

Christison (second edition, 1832) states that, "except the hydrocyanic acid, no poison is endowed with such destructive energy as the strychnia." He also describes the effects of the alkaloid upon animals, but is completely silent concerning its action upon the human subject. Richter, in 1834 (Ex. Wibmer, p. 250) relates a case of dangerous, though not fatal, poisoning caused by the medicinal use of strychnine. Blumhardt (*Med. Corr. Bl. des Würt. Ver.*, 1837, i.) was probably the first to record the death of a human being caused by strychnine; a man, aged seventeen, who committed suicide by taking two scruples (!) of the alkaloid. Orfila (1852) cites three other cases, one suicidal (in 1846), the other two accidental (in 1849, 1850), by mistake for salicin and santonin.

The first instance in which justice was called upon to consider strychnine as a cause of death, was the classical Palmer case, which occurred in England in 1855, although it seems probable that the same defendant had previously poisoned his mother-in-law in 1848, and his wife in 1854, by the same agent. Shortly after the inquest in the Palmer case, and while the secular press was discussing the possibility of detecting strychnine, a second poisoning occurred in England (case of Dove), which affords a striking instance of imitative poisoning, and of the ill effects of popular discussions of such a subject.

The meagre statistics concerning deaths by poison in recent years, which are available through board of health reports, coroners' returns, etc., indicate that poisoning by strychnine is even now of rare occurrence. A comparison of reports of criminal trials shows, however, that, notwithstanding its intensely bitter taste, strychnine is used with homicidal intent more frequently than any poison, except arsenic. Of 146 cases which were the subjects of criminal trials, 47 were by arsenic; 23 by strychnine; 14 by hydrocyanic acid; 10 by mercurials; 7 by sulphuric acid; and the remainder by other poisons (five cases, or less, of each).

SYMPTOMS.—The symptoms of poisoning by strychnine or nux vomica are very characteristic.

If the dose be relatively small, although capable of causing death, there is at first an initiatory stage of nervous exaltation without any violent symptoms, whose duration varies inversely with the magnitude of the dose and the rapidity of absorption. The special senses are much more acute than normally, the mental functions are active, the patient is restless, and experiences a sensation of itching.

Soon twitchings of individual groups of muscles occur, followed by violent tetanic convulsions. During the spasms there is, in the great majority of cases, marked opisthotonos. The head is thrown sharply back, the body bent backward, the abdominal and thoracic muscles firmly contracted, the lower extremities rigid, and the soles of the feet bent inward and strongly arched. The lower jaw is fixed, the eyeballs protruded, the pupils dilated, the expression of the countenance distorted, the lips cyanotic, the mouth marked with froth—frequently bloody from the tongue being caught between the closing teeth—and the neck swollen. In some exceptional cases emprosthotonos or pleurotonos is observed instead of opisthotonos.

The spasm gradually passes off, the muscles relax, the eyes and pupils become normal, and respiration is resumed. The patient speaks, usually calls for air, desires to be held, and is in dread of impending death. Indeed, consciousness and intellectual activity do not seem to be impaired during the spasms.

After the first convulsion others, similar in character, occur, either spontaneously or in consequence of very slight *unexpected* excitation. An attempt to move the patient, a slight jarring of the floor or bed, a sudden noise, a slight draught of air, or even a flash of light, is

sufficient to provoke a spasm if the patient do not expect it. On the other hand, much more active excitation fails to call forth a spasm if the patient be not taken unawares; and he frequently asks to be rubbed, held down, or moved. When the spasm recurs spontaneously, the patient usually announces its coming some seconds in advance, and asks to be held.

The number of convulsions varies from three to ten; their duration from thirty seconds to five or even eight minutes. The intervals vary in duration from forty-five seconds to one hour, or even one and a half hour; usually five to fifteen minutes.

In cases terminating in recovery the interval between the spasms increases in length, and the convulsions become less active and shorter in duration, and finally cease, leaving the patient in a condition of great muscular fatigue, and with increased reflex irritability. In fatal cases death results from one of two causes: In some cases death is due to asphyxia by fixation of the muscles of respiration during a protracted spasm; in others it is due to exhaustion, and occurs during the non-tetanic period. In most fatal cases death occurs during or after the fourth or fifth tetanic seizure, although cases have occurred in which the patient has succumbed at a later period, and others in which life was extinguished during the third, second, and first convulsion.

Duration.—The rapidity of action of strychnine is modified by the form in which it is taken, whether in solution or in a hard and difficultly soluble pill, and by the length of time which is allowed to elapse before treatment is resorted to.

In 49 cases, in which the time of first appearance of the symptoms was noted, the period was "directly, or very soon," in 12; from three to thirty minutes in 22; from thirty minutes to one hour in 7; from one to two hours in 6; and two and a half and three hours in 2. The average period of delay is, therefore, within twenty minutes. The extremes are "directly" and three hours.

The total duration of strychnine poisoning is also short, whether it terminate in death or in recovery. Of 40 fatal cases of which the duration is stated, 20 died within one hour; 8 in from one to two hours; 7 in from two to three hours; and 5 in from five to six and a half hours. In the majority of these cases the entire duration was less than one hour. The extremes were "immediately" (from a dose of one and three-fourths grain, combined with an equal quantity of nux vomica), and six and half hours (from a dose of three grains), both adult males.

The time elapsing between the beginning of symptoms and death has varied in 21 cases as follows: 8 within thirty minutes; 6 in from half an hour to an hour; 4 in from one to two hours; 3 in from two to five hours. The extremes are five minutes (male, aged twenty-six; dose five grains; symptoms began in fifteen minutes), and five and a quarter hours (male adult; dose three grains; symptoms began in forty-five minutes).

In non-fatal cases recovery is usually rapid, the active symptoms cease within a few hours, and, after cessation of the spasms, the patient may be considered as out of danger, although in exceptional cases great muscular prostration and occasional involuntary muscular contractions continue for some days.

Differential Diagnosis.—The disease bearing the closest resemblance to strychnine poisoning is tetanus, whether traumatic or idiopathic. In poisoning by strychnine the attack is more sudden than in tetanus, and the entire history of the case is compassed within a few hours, in place of lasting for days. The spasms follow each other at shorter intervals, and are of less duration, in strychnine poisoning than in tetanus. In the latter, trismus is one of the earliest and most prominent of the characters, while in the former it occurs later, if any succession of symptoms be observable, and may be insignificant as compared with the violent tetanic contraction of the respiratory muscles. During the intervals between the convulsions due to strychnine the muscles are usually relaxed, while in tetanus they remain more or less rigid, particularly those of the lower jaw. The chief points of distinction are in the much more rapid progress of strychnine poisoning, and, in the great majority of cases, in the history of the onset, which, in the poisoning, follows, with very little warning, within two hours or less, the ingestion of some bitter substance, but in tetanus is gradually developed several hours or days after an injury.

Uncertainty concerning the diagnosis between epilepsy and strychnine poisoning can only occur in the very exceptional case of an unknown person dying during a single convulsion. In such an event chemical analysis would decide the question definitely. In other cases the history of the case, the much longer interval between the paroxysms in epilepsy, and the more distinctly tonic character of the spasms in strychnine poisoning, are sufficient to establish the distinction.

In cases of poisoning of pregnant women by strychnine (two such are cited by Wharton and Stillé, pp. 443, 625), the distinctions between the effects of the poison and puerperal convulsions are of importance. The principal diagnostic point is in the fact that in puerperal convulsions the patient is entirely unconscious of what occurs, either during or between the convulsions, while in strychnine poisoning consciousness remains unimpaired, except immediately before death. The detection or non-detection of strychnine in the body would remove all doubts.

Lethal Dose.—The smallest amount of strychnine which has been known to cause the death of an adult is 0.016 gram (= ¼ grain), which produced violent symptoms in ten minutes in a female, aged thirty-six, and death in one hour and forty-five minutes (*Medical Times and Gazette*, 1854, p. 376). Double this quantity, 0.032 gram (= ½ grain), caused death in two cases. In one of these (case of Dr. Warner) a physician took by mistake half a grain of the sulphate, was violently convulsed in five minutes, and died in twenty minutes. Less quantities have produced dangerous poisoning in adults. Christison cites the case of a child of three years, which was killed in four hours by 0.004 gram (= $\frac{1}{16}$ grain).

On the other hand, numerous cases are on record in which much larger doses have been taken without causing death. Thus Campbell (*Lancet*, 1856, ii., 695) relates a case in which a man, aged thirty, took 0.65 gram (= 10 grains) of strychnine and recovered. Shaw (*American Journal of the Medical Sciences*, 1856, 547) cites the case of an adult female who recovered from the effects of a dose of 0.65 to 0.97 gram (= 10 to 15 grains). Tschepke (*Deut. Klin.*, 1861, ex "Maschka Handb.," ii., 613) gives a case of a pharmacist who took from 0.48 to 0.72 gram (= 7½ to 11 grains) of strychnium nitrate dissolved in about 30 grams (= fl ℥ j.) of bitter almond water, and, after half an hour, having experienced no symptoms, 0.6 gram (= 9¼ grains) of morphium acetate, also dissolved in bitter almond water. Subsequently, being still capable of locomotion, he poured chloroform upon his pillow and lay with his face upon it. An hour and a quarter after taking the first dose he suffered violent symptoms of strychnine poisoning, from which he, however, recovered under treatment by emetics and tannin. Atlee (*Medical Times and Gazette*, 1871, p. 283, ex *Boston Medical Journal*) cites a case in which the amount taken was probably the largest not causing death. The amount taken was 1.30 gram (= 20 grains), immediately after a meal. Emesis was provoked very soon after.

Treatment.—The ends to be aimed at are, first, the removal of any unabsorbed poison from the stomach, if possible, and, second, the prevention or mitigation of the paroxysms. For the attainment of the former an emetic of zinc sulphate or of apomorphine should be given, if the case be seen early, followed by tannin, with the view of converting any remaining strychnine into an insoluble compound. Chloral should be generously administered, followed by inhalations of chloroform sufficient, and sufficiently prolonged, to control the convulsions until the poison shall have been eliminated, as it is with considerable rapidity. In the exceptional cases in which the patient is seen before the tetanizing action of the poison has been established, the stomach should be washed out as expeditiously as possible with a strong infusion of tea, or a solution of tannin in some form, or water holding

powdered charcoal in suspension. No reliance is to be placed upon camphor, albumen, opium, aconite, cannabis indica, or tobacco, which have been suggested as so-called physiological antidotes.

Post-mortem Appearances.—There are no peculiarities discoverable, on external or internal examination, which are characteristic of this form of poisoning. Rigor mortis is more rapidly established and continues for a longer period in most cases. According to Wharton and Stillé, rigor mortis was very marked in the body of a woman exhumed two weeks after death (*Medical Jurisprudence*, ii., 445). Taylor ("Poisons," third American edition, 676) states that cadaveric rigidity was well marked in the body of Cook two months after death. Usually the body is relaxed at death and soon stiffens, but in some cases the tetanic spasm merges into rigor mortis. But instances are met with in which cadaveric rigidity has disappeared in from twenty-four to forty-eight hours. In some cases the hands are firmly clenched and the soles arched after the other muscles have become relaxed. Rigidity is of shorter duration in the bodies of those in whom the spasms have been more or less controlled by treatment during life, than in those who have died without medical interference. The surface is usually livid, but not in all cases. Sometimes lividity is confined to the fingers, and in some cases the inner surfaces of the thighs and arms assume a red color.

The internal appearances are still less characteristic. The blood is usually fluid, and dark. The vessels of the scalp, the brain and its coverings, and of the spinal cord, as well as the lungs, are in most cases congested. The heart is usually empty and sometimes firmly contracted, the right side being less so than the left, and sometimes distended with dark, fluid blood. The bladder is usually empty, though in some cases it has been found to be nearly full of urine. Occasionally ecchymotic spots or patches of congestion are observed in the stomach.

Analysis.—In cases in which the analysis is not to be limited to a search for strychnine, the systematic method of Dragendorff for the separation of alkaloids and glucosides from organic mixtures (see Vol. V., p. 764) should be followed. By this method any strychnine which may be present in the substances examined will be found in the residues of evaporation of the petroleum-ether and benzol extracts from the alkaline aqueous solution.

In all cases it is advisable to resort to Dragendorff's method, even when the history of the case points very directly to strychnine, as any question subsequently arising as to the presence or absence of another alkaloidal or glucosidal poison can then be determined.

In some exceptional chemico-legal cases, and when the physician wishes to determine the presence or absence of strychnine in the urine during the life of the patient, an abridged modification may be used. If the substances to be examined be solid, they should be finely divided and placed in a flask, to which water, rendered distinctly acid with sulphuric acid, is added in sufficient quantity to cover the solid. After agitation, the reaction of the liquid is to be determined, and if not distinctly acid, it is to be rendered so by the addition of dilute sulphuric acid. The flask and its contents are then to be placed in an oven heated to 40°–50° C. for six or eight hours, after which the liquid is to be filtered off. A fresh portion of dilute acid is to be added and the extraction repeated four or five times. The united acid filtrates, which contain any strychnine that may be present in the form of the sulphate, are then evaporated to the consistency of a thin syrup over the water-bath. The residue is mixed with four volumes of strong alcohol, gradually added during stirring, and allowed to macerate twenty-four hours. The alcoholic liquid is filtered off, the residue on the filter washed with strong alcohol, and the filtrates and washings evaporated over the water-bath until free of alcohol. The residue, thinned with water if necessary, is transferred to a stoppered cylinder. The solution should not exceed 100 cc. in bulk, and may be less. About 50 cc. of benzol (boiling-point not over 85° C.) are then added and the cylinder strongly agitated once every five minutes for about half an hour. The benzol layer is then removed by the separatory funnel and a fresh portion added to the aqueous liquid, which has been returned to the cylinder. This extraction of the acid aqueous liquid is repeated (usually four or five times) until the benzol no longer leaves a residue on evaporation. The purpose of this extraction is to remove pigmentary and other substances, whose presence materially interferes with the reactions. The aqueous liquid is now rendered distinctly alkaline with ammonium hydrate, and again repeatedly extracted with benzol as described above, but the benzol layers now separated are evaporated in several watch-glasses, and it is to the residues so obtained that the tests for strychnine are to be applied.

If the substance to be examined be a liquid, it should either be evaporated to dryness, the residue extracted with acidulated water, and the filtered aqueous extract treated with benzol, the watery solution being first acid, then alkaline, as above described; or, in the case of a simple aqueous solution, the treatment with benzol may be applied directly, care being had as to the reaction.

In order that the tests may be relied upon, particularly when the alkaloid is present in small amount, as in the case of absorbed strychnine, it is essential that foreign substances be removed as completely as possible. Therefore, if the benzol residue from the alkaline solution be colored, it should be purified by dissolving it in a small quantity of dilute sulphuric acid, agitating with benzol, rendering alkaline, and again extracting with benzol.

Tests.—1. The crystalline form was formerly much relied upon. Strychnine crystallizes from an alcoholic solution in small, four-sided, orthorhombic prisms, terminating in four-sided pyramids; sometimes also in small hexagonal plates. Precipitated by ammonia from solutions of its salts, it forms slender, needle-like, four-sided prisms. As, however, many other substances crystallize in the same form, and as, when the alkaloid is present in very small amount and other substances are present, or when the solvent is rapidly evaporated, the form of the crystals may be modified, or they may not be produced at all, the presence or absence of crystals can only be considered as confirmatory evidence.

2. The taste of strychnine is intensely and persistently bitter, with a faintly metallic after-taste. The bitter taste is still perceptible in a solution containing only one part of strychnine in six hundred thousand of water. The value of this quality is simply confirmatory, as there are many substances other than strychnine whose taste is bitter.

3. Strychnine dissolves in concentrated sulphuric acid, forming a colorless solution of the sulphate. If, now, nascent oxygen be generated in the solution, a peculiar play of colors is produced; at first, and but for an instant, blue (this is sometimes absent), then violet, which gradually changes to red, and then to yellow.

This test, which is most delicate and characteristic, may be applied in a variety of ways.

The sulphuric-acid solution may be placed upon a strip of platinum foil connected with the positive (platinum) pole of a single Grove cell, and a platinum wire, connected with the negative (zinc) pole, brought into contact with the upper surface of the drop of liquid. The nascent oxygen liberated at the foil produces a purple-violet blotch.

The sulphuric-acid solution may be placed in a watch-glass upon a white background, and a minute fragment of some solid substance capable of yielding oxygen by contact with sulphuric acid drawn through it with a stirring rod. The path of the solid is marked by a streak of color passing through the shades above mentioned. Either black oxide of manganese, oxide of cerium, permanganate of potassium, dichromate of potassium, ferricyanide of potassium, or peroxide of lead may be used. Black oxide of manganese and dichromate of potassium are preferable to the other substances mentioned, and both should be used with separate portions of the residue, if there be sufficient. The dichromate acts quite rapidly, the blue color is not produced, and in solutions containing no strychnine only a yellow color is communicated to the liquid. The oxide of manganese acts much more

slowly by reason of its less solubility, the blue color is developed, and, in the absence of strychnine, the liquid remains colorless.

The only substance producing a similar play of colors under like treatment is curarine, the alkaloid of the South American arrow poison. But the change of colors with that alkaloid takes place much more slowly than with strychnine. Curarine is, moreover, colored red by sulphuric acid alone, while strychnine forms a colorless solution with the acid. Any possibility of error is avoided if the method of separation above described have been followed, because curarine is not extracted from either acid or alkaline aqueous solution by petroleum-ether or benzol, but remains in the aqueous liquid.

Aniline also gives a blue-violet color with potassium dichromate and dilute sulphuric acid, but this color does not change to red and yellow, but to black; while a peculiar odor, somewhat resembling that of bitter almonds, is given off, which is not observed in the case of strychnine.

The reaction is interfered with to a greater or less degree by the presence of sugar, morphine, or other reducing agents, brucine, and other substances; therefore the foreign bodies should be removed as completely as possible before the test is applied.

This color reaction is distinct with $\frac{1}{600000}$ grain of strychnine.

4. The physiological test, first suggested by Marshall Hall, is also extremely delicate. A small frog is well dried and held by the hind legs, the skin of the back over the coccyx is raised by a pair of forceps, and a small incision made through the skin into the lymph-pouch with a pair of pointed scissors. A few drops of the solution under examination are then allowed to flow from a pipette into the lymph-pouch, and the animal is placed under a glass shade. If the liquid contain strychnine the animal becomes uneasy in about ten minutes; the respiration is accelerated; and violent tetanic convulsions are provoked by striking upon the table, by blowing upon the animal, or by other slight irritations.

5. A solution of iodic acid in concentrated sulphuric acid colors strychnine brick-red, the color changing to violet.

6. Solution of potassium dichromate causes a yellow, crystalline precipitate in solutions of strychnine or of its salts. If this precipitate be moistened with sulphuric acid, the play of colors described in 3 is produced.

Other reactions of strychnine are the following: With solutions of the alkalies, or alkaline carbonates, a crystalline precipitate of strychnine from moderately concentrated solutions of its salts. With tincture of iodine, or solution of iodine in potassium iodide solution, a dark red-brown precipitate. With platinic chloride and with auric chloride, light-yellow precipitates, gradually becoming crystalline. With potassium-iridium chloride, a dark-brown precipitate, which disappears on agitation, but gradually reappears in the form of crystals. With potassium platinocyanide, a white, crystalline precipitate. With potassium-cadmium iodide, a white, flocculent precipitate. With potassium iodhydrargyrate, a fine, white precipitate. With phosphomolybdic acid, a yellowish-white precipitate. With picric acid, a yellow precipitate, which gradually becomes crystalline. With tannic acid, an abundant, white precipitate.

Failure of Detection.—The reactions of strychnine are clearly defined, and it is difficult to suppose a case of death from the effects of this poison in which a properly conducted analysis would not reveal the presence of the alkaloid in the cadaver. It is unquestionable that death may result from the action of certain corrosives and poisons, without any trace of the substance remaining in the body after death. In cases in which a mineral acid or alkali destroys life by starvation, weeks or months after the corrosive has been taken, and in cases of death from digitalis, on the fifth or sixth day, the agent which was the remote cause of death has been eliminated before the fatal termination, and consequently will not be detectable by analysis. The duration of a fatal case of strychnine-poisoning is, however, so short (the maximum lapse of time being six and a half hours, and the average less than one hour from the taking of the poison) that it is, to say the least, highly improbable that a person should die from the effects of this poison and no trace of it remain in the body.

Yet cases have occurred in which death has been undoubtedly due to strychnine, and an analysis has nevertheless failed to reveal the presence of the alkaloid in the cadaver. An historical instance is the case of Palmer, tried in London in 1856, in which Professor Taylor, who made the analysis, did not obtain chemical evidence of the presence of strychnine, although the deceased, Cook, was seized with violent tetanic convulsions fifty-five minutes after taking the poison, and died in about fifteen minutes thereafter. The failure of this analysis (for such it must be considered, as complete elimination in so short a time is not possible) was the subject of much bitter controversy, and seems to have permanently warped the mind of Dr. Taylor on the subject of chemico-legal evidence. It was due to two causes, both avoidable. The autopsy was conducted without the commonest precautions necessary in such cases. The defendant was present, and accidentally (?) caused the loss of the contents of the stomach; and the solid viscera were only obtained for analysis at a later date. But the loss of the contents of the stomach, although they probably contained strychnine in larger quantity than the tissues, would not have caused complete failure of the analysis had the analytical processes been properly conducted. In a case of compound poisoning by arsenic and strychnine, in which the analysis was made by the author in conjunction with Professor C. A. Doremus, no evidences of the presence of the alkaloid were obtained with the residues (by the Dragendorff method) first obtained, but on suitably purifying these residues, positive reactions were observed in the contents of the stomach, those of the intestines, and in the liver, kidneys, and heart.

When the amount of strychnine present is large, positive reactions may be obtained even in the unpurified residues; but when the amount is small, as it must necessarily be when absorbed, it is imperative that the alkaloid be freed from other substances as completely as possible before the tests are applied.

Influence of Putrefaction.—Strychnine is one of the most stable of the alkaloids, and remains unaltered in contact with putrefying animal substances for a long time. Cloetta obtained distinct reactions from viscera containing strychnine which had been buried three, six, and eleven and a half months (*Arch. f. Path. Anat.*, Bd. xxv., p. 369). Rieckher (*Zeitsch. f. Anal. Chem.*, vii., 400) demonstrated the presence of strychnine in a mass of heart, lung, and liver exposed to the ordinary variations of temperature, with which it had been mixed eleven years previously. *R. A. Witthaus.*

STUTTERING. Stuttering is a functional speech defect, consisting of clonic or tonic spasm of the muscles of respiration, phonation, and articulation, induced by the attempt to utter articulate sounds.

The intensity of the spasm varies greatly in different cases, from a scarcely noticeable impediment in speaking, to an attack which renders speech for the moment impossible. The disturbance results in closure of the air-passages, which is with difficulty overcome by the patient, and usually occurs in connection with the explosive consonants, in producing which there is normally a closure either by the lips, by the tongue, or by the soft palate. It may, however, occur with the pure open sounds, or before a sound has been uttered, in which case the spasm originates at the glottis. There may or may not be a repetition of the offending sound, but there is apt to be when it is one of the explosives.

The attacks occur irregularly, and are much influenced by circumstances. Thus a stutterer may be able to converse easily with his friends, but be unable to bring out a syllable when talking with strangers. Or he may be able to carry on an ordinary conversation, but have trouble in telling a story, or making any prolonged effort at speech. One may stutter only when tired or slightly out

of health. Stutterers are usually exempt when whispering or singing, but this rule has frequent exceptions.

Stuttering has been known from the earliest times, but has been generally confused with other speech defects, so that it is often impossible to tell whether an account relates to this, or to aphasia, or to stammering. It differs from the latter in origin, is never due to organic defect, nor entirely to carelessness, is intensified when the patient's attention is directed to his speech, or when he is embarrassed, and it is only occasional, while stammering is regular. Under favorable circumstances the stutterer's enunciation is perfect. It is evident, then, that it is no mere defect of articulation, nor of co-ordination, for the muscles at times harmonize perfectly in their action.

Stuttering is mentioned by Hippocrates, Aristotle, and Galen, but in a somewhat indefinite way. We are told by Plutarch that Demosthenes had a difficulty of enunciation, which he overcame by declaiming as he walked up hill, and by holding pebbles in his mouth as he rehearsed his speeches. The latter plan has points of resemblance with modern devices, as we shall see ; but it is not at all certain, from the account, whether the defect which it removed was really a stutter, or some form of stammer. At any rate, he adopted an excellent form of respiratory gymnastics, which are the foundation of most of the modern systems of treatment.

During the Middle Ages, writings on the subject appeared occasionally, imputing the trouble to malformation of the tongue, cerebral disease, etc., but no work of importance was done until the beginning of the present century.

Itard (1817) divided stuttering into two classes, congenital and accidental. Under the latter head he included all speech defects due to cerebral lesion or organic disease of the tongue. It will be seen that this included what is now known as aphasia. In the congenital form he considered weakness of the organs of articulation as accompanying, not causing, the difficulty. He recommends beginning treatment early, and teaching the child slowly and carefully the pronunciation of a foreign language, dropping for a time its own. In this way he is taught, from the very first, to combine sounds properly, and to give prominence to the vowel sounds rather than to the consonants.

In 1825, Mrs. Leigh, of New York, discovered a method of treatment which was kept for a long time secret. Her observations were made on the daughter of a physician in whose house she was governess, and she afterward established an institute for the cure of stutterers. She thought the trouble due to a faulty position of the tongue, which is spasmodically depressed during the attack. To overcome this, she taught her patients to voluntarily raise the tip of the tongue, and keep it in this position while speaking. Her results were at first surprisingly good, and attracted a good deal of attention, as well throughout Europe as in this country.

Malebouche bought Mrs. Leigh's secret, and carried it to Europe. He attempted to improve on it, but only succeeded in altering it in minor details. He taught the system in Brussels, and finally sold it to the Prussian Government, who went so far as to appoint a professor of it. It was reported on by Magendie in a communication to the French Academy. He thought its value only temporary.

In 1826, McCormack, unable to learn Mrs. Leigh's secret, set to work to discover it for himself. He arrived, however, at a different conclusion, namely, that the trouble is one solely of respiration, and that it is only necessary for the stutterer to fill his lungs well with air before each sentence.

M. Serres d'Alais (1829) published a more scientific résumé of the subject, in which he divided the cases into two classes :

1. Those due to a stiffness, as if tetanic in character, of the muscles of the voice and respiration.

2. Those due to a chorea of the muscles of articulation. He recommended in severe cases gymnastic movements of the arms while speaking; in light cases he considered it sufficient to pronounce the syllables in a short and brusque way, at the same time making the movements of articulation as extended as possible. He admitted that recovery is never quite complete, differing in this respect from most writers of the time, who, skeptical as to the statistics of others, claimed infallible results from their own particular method of treatment.

Chégoin (1830) anticipated by some years the rage for operation which was afterward to sweep through Europe. He thought the trouble entirely due to malformations of the tongue, consisting in either a real shortness of the tongue or a faulty position of the frænum, which then binds the tongue too tightly to the floor of the mouth. He recommended cutting the frænum, but thought the operation beneficial only when performed early, soon after the child has begun to talk. For shortness of the tongue he thought a silver plate on the teeth might be of service.

Arnolt (1830) ascribed the difficulty to spasmodic closure of the glottis. To overcome this he caused his patients to make a *ŭ* sound between the words, so as to bind the consonant rather with the preceding than with the following vowel sound. In this way he threw the consonant sounds into the background, as one does in singing.

At about this time Colombat, in France, attracted a good deal of attention by his brilliant success in treatment. He claimed to have cured one case in a single sitting of three hours, but, in a later edition of his work, considerably modified this statement, and other authorities say the case relapsed several times. In fact, so many tables of statistics have been compiled from the immediate results of treatment, without waiting to see whether relapse occurred, that they are almost entirely worthless. Colombat gives a classification of cases much like that of Serres d'Alais, into :

1. Repetition of syllables due to convulsive movements of the tongue and lips, or labio-choreic form.

2. Tetanic stiffness of the muscles of respiration, or gutturo-tetanic form. For the first form he recommends the use of a rhythmical movement of the thumb and index-finger during speech, and an instrument for beating time, of his own invention, called the muthonome. If the case is complicated by gutturo-tetanic spasm, he adds "lingual and guttural gymnastics, which consist in taking a deep breath before difficult words and phrases, and bringing the tongue into the pharynx, at the same time raising the point well toward the velum palati." His method is, after all, only a combination of preceding ones, but seems to have been effectual in producing, for a time at least, very good results.

The year 1841 is unique in the annals of this affection. In that year operation was proposed, hundreds of stutterers were operated on, but before the end of the year the surgeons themselves were convinced of the uselessness of operation. The idea was suggested to the mind of Dieffenbach, of Berlin, by the frequency with which stuttering and strabismus exist in the same patient, and occurred to him, he says, when a man asked, with a marked stutter, to be operated on for strabismus. The operation which he usually performed was section of the root of the tongue, sometimes with excision of a triangular piece throughout its entire length and breadth. This proceeding was based on the theory that stuttering is a purely local affection. The news of these operations soon spread to France, but at first without details, and there several others were invented, *e.g.*, cutting the hyo-glossi, genio-glossi, etc., varying with the different theories of the surgeons as to the cause of the trouble. At first cases were reported as cured by each of these methods. Later, relapses were said to have occurred. Then several deaths were reported, and operation was soon abandoned as useless by common consent. Dieffenbach himself admitted the extreme danger of the proceeding. The deaths were the result of secondary hæmorrhage and gangrene. The results attained immediately after operation seem to have been due to the impression on the nervous system of the patient, which wore off as soon as the effects of the operation subsided.

Since that time there has been a good deal written on the subject of stuttering, largely by stutterers them-

selves, both in and out of the profession; by Guillaume in France, Merkel, Klencke, and Kussmaul in Germany, Canon Kingsley and Bristowe in England, Hammond and Potter in America, and many others.

Guillaume lays especial stress on the disturbances of respiration. He points out the fact that the ordinary expiratory act is passive and simply elastic, while in speaking the inspiratory muscles are innervated during expiration, so as to allow only so much air to pass out as is necessary for phonation. The stutterer often expends his whole stock of air in one syllable. His lungs are then empty, and a deep inspiration is prevented by spasm of the glottis or irregular action of the diaphragm. Guillaume recommends a breathing exercise, consisting of a deep inspiration, held awhile, and followed by an expiration, slow and interrupted as in speech, but without sound. He also recommends fixation of the tongue high, a deep inspiration at the beginning of every clause, and the use of an interdental plate. The latter, he says, sometimes wonderfully changes a stuttering pronunciation.

Merkel lays especial stress on the fact that the difficulty lies in combining a consonant with the following vowel sound. He locates the trouble, not in the articulating, but in the vocalizing apparatus, or, farther back still, in the nerve-centres which govern that apparatus.

Gerdts thinks the trouble one of respiration. He says, however, that the spasm is induced by the patient using the mouth instead of the throat in talking. His idea seems to be to make vocalization more, and articulation less, prominent. At the same time he pays great attention to the breathing, which, he says, has been faulty, even when not speaking, in all of the 690 stutterers whom he has treated.

Bristowe likens stuttering to chorea.

Causation.—Among the many theories which have been propounded to account for the symptom under discussion, that which ascribes it to malformation or disease of the organs of articulation is one of the oldest, and one which held its ground longest. It is the foundation of all operative interference, and is readily disposed of. In many pronounced cases of stuttering the tongue and lips execute ordinary movements perfectly. No abnormality is noticed except during speech; and when organic trouble coexists, its removal does not entirely cure the affection. Any conceivable degree of deformity may exist and cause nothing but stammering, which is then proportional to the amount of the lesion.

Stuttering is not due to a faulty position of the tongue, as is shown by the constant relapses which occurred after treatment by Mrs. Leigh's method. It is true that in many cases the tongue is pressed against the floor of the mouth, and is affected with clonic spasm in this position. This is, however, not always the case, and when it exists it is a result, not the cause, of the malady.

The trouble is not a chorea of the muscles of articulation. The characteristic of choreic spasm is that it is irregular and jerky, and occurs during rest. The spasm of stuttering occurs only during a voluntary excitation of the speech-mechanism. Again, chorea, when it affects the lips and tongue, causes marked stammering, never stuttering. Chorea of the speech-centre, or coprolalia, causes a spasmodic ejaculation of words or phrases independently of volition, and the words are perfectly articulated.

That the trouble is due to confusion of ideas, or disproportion of words and ideas, is obviously false. Stuttering occurs in persons of every grade of mental power. The greatest disproportion between words and ideas occurs in acute mania, and leads, not to stuttering, but to a chaotic mixture of words and syllables. In most persons failure of ideas is marked by a drawl, not a stutter.

It is not due to a simple ataxia of the muscles used in speech. If it were, the patient could at once control the irregular movements by ceasing to speak. But when he does this, the spasm invariably persists for a short time. Again, stuttering is only occasional, and made worse when the patient's attention is directed to his speech; ataxia is constant, and is diminished by attention.

The theory that it is an inability to combine the consonant and vowel sounds is inadequate to explain the symptoms. The occasion of so combining them is often a proximate cause of an attack, somewhat as general convulsions are caused by teething or other peripheral irritation. But stuttering may occur on an attempt to utter a pure vowel sound entirely apart from a consonant.

In order to understand the phenomena presented, it will be necessary to review briefly the structure and physiology of that part of the motor speech-centres which serves for the production of articulate sounds. The processes which occur in the nerve-centres during speech are most of them unconscious, there being present to the mind only the primary volition, which is comparatively simple. The act of speech is based on stored-up motor memories of former acts of the same kind, which originated in childhood in reflex and accidental movements, perceived by the child, and afterward voluntarily executed. The details of these movements are carried out by a co-ordinating mechanism which has acquired its functions gradually, as a result of training. The motor impulse travels from the motor speech-centre in the left third frontal convolution, downward through the knee of the internal capsule, and reaches the medulla. The nerves carrying it here communicate with the articulo-respiratory centre, consisting of the nuclei of origin of the facial, pneumo-gastric, spinal accessory, and hypo-glossal nerves. These nuclei lie close together, and constitute practically one collection of cells bound together by fibres running in every direction. Here, and possibly also in the cerebellum, is effected the exact degree of innervation of all the muscles of articulation, so as together to produce the vowel and consonant sounds, and at the same time to approximate the vocal cords, and so regulate the respiration as to cause exactly the necessary amount of air to pass through the glottis. This exceedingly complex action is entirely apart from the conscious act of speech, and is only known to the sensorium through the intervention of the sensory nerves supplying the mucous membranes and deeper parts of the lips, tongue, and palate. It is one of the highest reflex actions, and, like most reflexes, is more or less under control from the cerebrum. The amount of innervation of each muscle is determined by lines of least resistance in the connecting fibres, which are formed as a result of repeated transmission of motor impulses, and are determined to a considerable extent by predisposition.[1] This whole system is probably under the influence of one or more controlling centres, which serve to check over-action, or the undue diffusion of nerve-force.

Stuttering is a disturbance of this co-ordinating mechanism. It may be due to abnormal excitability of the primary system, or to weakness of the inhibiting centre, probably the latter. The result is an over-action of the muscles innervated, and transmission of the impulse to other muscles more or less distant, sometimes even to those of the arms and trunk; the attempts of the patient to overcome the spasm only serve to intensify it, until the controlling centre resumes its function, or the patient ceases the effort to speak.

Several facts tend to show that the trouble is adynamic in origin—*e.g.*, the fact that patients usually stutter worst when tired; that persons sometimes stutter when exhausted, or during sickness, who do not otherwise; that stutterers are often, though not always, of weak or scrofulous constitution. The inhibiting influence of strong peripheral impressions, as seen in the results of operation on the tongue, is somewhat like the stoppage of epileptic convulsions by ligature or an encircling blister of a limb.[2]

This disturbance of equilibrium between the centres is often the result of an inherited tendency. It may follow severe illness, fright, or any shock to the nervous system. In such cases the trouble may pass off when the depressing influence ceases, or may persist for a long time, or through life. In any case the intensity of the disturbance depends much on the treatment and surroundings of the patient, anything like ridicule or punishment aggravating it tenfold.

OCCURRENCE.—Stuttering occurs in all ranks of society, and in most nations. The Chinese are said to be exempt, on account of the peculiar intonation of their language. It affects men much oftener than women, although trustworthy statistics on this point are lacking. Some authorities have thought that no women stutter; others place the proportion of women affected as high as thirty-five per cent. Kussmaul believes the fact to be due to the greater tact and delicacy of women, which fits them more readily in every way for their place in society.

SYMPTOMS.—These vary much in point of severity and mode of sequence of the spasm. In lighter cases, which are fairly under control, when one of the explosive consonants is met with, the organs of articulation remain fixed in their closed position for a moment, there is slight choking, and tremor of the facial muscles, an effort of the will is made, and the parts resume their function.

In rather more severe cases there may be added a good deal of thickening and tremulous movement of the tongue, and tonic spasm of the glottis. The breathing is then apt to be irregular, and the approximation of the vocal cords causes a crowing sound on inspiration, which is sometimes utilized for speech.

When the spasm occurs before speech has actually commenced, the trouble begins with tonic spasm of the glottis, there is tonic and clonic spasm of the tongue, lips, and face, and the diaphragm acts irregularly in its efforts to overcome the resistance at the rima glottidis.

In severe cases the attack may be brought on by any sounds, less frequently the open vowel sounds; the closure may be effected by the lips, tongue, or palate; the under jaw is set; there is marked tremor of the facial muscles, and sometimes even of the arms; the glottis may be closed so as almost or entirely to prevent respiration, or it may be opened at the same time that there is spasm of the respiratory muscles. In the latter case the lungs are emptied of air, and the patient must pause for a deep breath before he can proceed with his sentence. At the same time the face becomes flushed, the flow of saliva is increased, and the mental torture of the patient tends to prolong rather than cut short the attack.

DIAGNOSIS.—The diagnosis is usually easy. In addition to the clinical features given above, the duration of the malady should be carefully ascertained.

Stuttering almost invariably dates from childhood. Attention should be paid to the physical signs of organic brain disease.

The speech-defect which occurs in paretic dementia may simulate stuttering quite closely. There is here faulty enunciation of the separate consonant and vowel sounds, with marked tremor of the tongue and facial muscles. But there is not much disturbance of respiration; the tremor of the tongue and lips occurs when the patient is not speaking; above all, there are elision of syllables, and other evidences of partial aphasia. The history shows a recent development of the trouble.

On the other hand, stutterers with congenital mental defect and unequal pupils have been mistaken for paretics. Absence of other symptoms, stationary nature of the disease, and attention to the differences given above will then decide.

In clergymen and other public speakers there sometimes occurs a difficulty in speaking, which may be mistaken for stuttering. It is one of the occupation neuroses, of which the type is writers' cramp, and is due to exhaustion of the co-ordinating mechanism of respiration. Respiration, as pointed out above, is ordinarily reflex, but becomes voluntary when used for speech. Some speakers entirely empty their lungs before taking breath; the action of the reflex mechanism is then kept too long in abeyance. When this is habitual, the centres become exhausted and fail to respond to the reflex stimulus. The trouble usually begins in the glottis, which fails to open on inspiration; a crowing sound is produced when the speaker takes breath; the diaphragm and intercostals act weakly and irregularly, and the lungs cannot be promptly filled for the next sentence. This may happen only toward the end of the discourse, when the speaker is tired, but may become so marked that any attempt to speak causes great distress, and rest is then an imperative necessity. This affection differs from stuttering by occurring comparatively late in life, not involving the muscles of articulation, being rather of a paralytic than of a spastic nature. It ordinarily yields to rest and respiratory gymnastics.

Another rare affection, aphthongia, is probably allied to the preceding. Here the spasm occurs in the muscles supplied by the hypo-glossal nerve, and is brought on by any attempt to speak, so that articulation is rendered impossible. In the few cases recorded the disease has been caused by emotion or fright. During the attack the jaws and tongue are fixed; the sterno-thyroid, sterno-hyoid, and thyro-hyoid muscles may be in a state of clonic spasm, which begins and ceases with the attempt to speak. The prognosis seems to be good. Too little is known of the disease to speak of its probable relation to stuttering. It may be distinguished by the character and history of the attacks.

The speech-defects in multiple sclerosis, bulbar paralysis, etc., have been noticed in a previous article. (See Stammering.)

PROGNOSIS.—There is no doubt that sufferers from this affection may be aided by treatment, especially if the latter is vigorous and instituted early. The prognosis is better in non-hereditary cases, and in patients of strong will-power. Almost all writers on the subject have a favorite method of treatment, especially those who are connected with an institute for voice-training, and claim a large percentage of cures. Investigation shows that in most cases relapse takes place, after an even brilliant result. This should not discourage patients from effort, but it is necessary to bear in mind that only constant and long-continued exertion will overcome a vicious tendency fixed by habit. The difficulty tends to decrease with time, and many stutterers are able to master it at forty or fifty years of age. They are apt to ascribe this to some particular form of treatment, which they then ardently recommend.

TREATMENT.—Too much stress cannot be laid on beginning treatment early. The child should be kept, as much as possible, from association with stutterers. It should be remembered that he is sensitive as well to sympathy as to blame for his malady, and as little notice should be taken of it as possible, except in connection with stated lessons. He should be taught, when he has an attack, to stop speaking at once until he has mastered it.

Breathing exercises are very important. They may be given, following Guillaume, by causing the patient to take a long breath, hold it for a moment, and then let it out slowly, with occasional stops, but without sound. He should especially be made to take a deep breath at frequent intervals, and never speak with nearly empty lungs.

After breathing exercises have been continued for some time, the patient may proceed to the vowel sounds, first the most open one, *ä*, then *ā*, *ă*, *ĕ*, *ē*, *ō*, *ŏ*, and so on; then the aspirates, *hä*, *hā*, etc.; next the easier consonants in combination, *lä*, *lā*, *lē*, *lō*, *lū*, *mä*, *mā*, etc. Sentences may then be used in which the difficult sounds do not occur. Lastly, the explosives, *dä*, *dā*, *bä*, *lā*, etc., may be tried. With all of these the patient should be taught to lay the stress on the vowel sounds, so as to avoid the slight over-action with the consonants, which is usually the beginning of the spasm. One must be sure that the pupil has mastered each of the above classes before he is permitted to go on to the next.

We have a mass of evidence from stutterers, in the profession and out of it, testifying to the efficacy of rhythmical movements accompanying speech. They serve a twofold purpose—they divert the patient's attention, and give his sentences something of a sing-song character. They are aids, but are in no sense curative. The thumb and finger may be opened and closed, or any other movement made which is convenient to the patient. Somewhat the same effect is produced by elevating the tip of the tongue, as recommended by Mrs. Leigh, but it will

be better, in most cases, to draw the patient's attention to a more distant part of his body.

Therapeutic measures are of little value. Stimulants should be used moderately, if at all. Scrofulous and anæmic tendencies should be corrected, and the patients should be kept in good general health by exercise, cold sponging, and like measures.

The question is often asked, whether it is possible for an adult to master his defect without assistance from a teacher. That is entirely an individual matter. Some men have perseverance enough to educate themselves in this as in other respects. Proper teaching, however, saves much time and disappointment.

The following works may be consulted for further details:

Guillaume: Dictionnaire encyclopédique des Sciences médicales, art. Bégaiement.
Kussmaul: Störungen der Sprache.
Lehwess: Radicale Heilung des Stotterns.
Merkel: Physiologie der menschlichen Sprache.
Potter: Speech and its Defects.

Henry S. Upson.

[1] Gowers: Diagnosis of Diseases of the Brain.
[2] Compare Buzzard: Lecture on Transfer caused by Encircling Blisters.

STYPTICS are medicines used locally to arrest hæmorrhage. They have the property of forming, with the albumen of the escaping blood, a solid, more or less adhesive mass, or coagulum, which mechanically closes the bleeding vessels. Of the numerous substances which coagulate albumen only the following are commonly employed: Tannin, alum, chloride of iron, subsulphate of iron, iodine, and nitrate of silver.

Their utility is very conspicuous in hæmorrhages from small blood-vessels, especially capillaries; but when a rapid flow of blood takes place from large arteries, they are quite powerless and should not be employed, unless other efficient hæmostatics cannot be applied.

Acidum Tannicum.—The coagulum which tannin forms with albumen adheres quite firmly, and usually quickly occludes small vessels. It is generally held that tannin also contracts the vessels; but in a series of very careful experiments it was found by Rosenstirn that even very concentrated solutions markedly dilate arteries, veins, and capillaries.

Tannin used as a styptic does not produce any notable irritation of the tissues, and causes neither pain nor subsequent inflammation. It is, therefore, preferable to other more irritating substances. It is most effective when applied in the form of fine powder immediately to the bleeding surface, all coagula having previously been removed by means of cold water.

It is often successful, even when it cannot be brought in contact, in large quantities, with the bleeding surface. Thus epistaxis commonly ceases after it has been snuffed up the nostrils. Concentrated solutions also sometimes arrest epistaxis.

To arrest bleeding after tooth extraction, finely powdered tannin should be freely applied to the bleeding surface by means of a piece of soft, moist sponge, or a pledget of cotton. Then a thick narrow compress should be applied over the sponge or cotton, and the jaws firmly closed by means of a roller passed around the head.

Tannin is used in metrorrhagia when the blood issues from small vessels of the cervix uteri. Several drachms are usually applied by means of a mass of cotton previously soaked in water and squeezed nearly dry, or by a soft, moist sponge. Sometimes suppositories of tannin, made with a small quantity of glycerine, or with oil of theobroma, are introduced into the cervix. Becquerel used suppositories consisting of tannin, four parts; tragacanth, one part; and bread crumb, a sufficient quantity. He applied them through a speculum, and kept them in place, until dissolved, by a mass of cotton saturated with a concentrated solution of tannin.

Tannin has also been employed in gastric, intestinal, and pulmonary hæmorrhage. Its utility in gastric hæmorrhage is very doubtful, as it probably cannot come into close contact with the bleeding surface. It should be tried only in cases in which the blood issues from small vessels, and administered in the form of powder or concentrated solution. In intestinal hæmorrhage, especially when the bleeding surface is in the lower part of the small intestine, as in typhoid fever, it is useless. If given, the pilular form of administration should be preferred. In hæmoptysis inhalations of atomized solutions of tannin, containing from one to ten per cent., are said to have been successful, especially in cases in which the bleeding was moderate but recurred frequently.

Alumen.—Alum may be employed in hæmorrhage from small vessels of any accessible part.

In epistaxis powdered alum, either pure or mixed with an equal quantity of gum arabic, may be blown into the nose by means of an insufflator or a paper funnel, or a saturated solution may be thrown into the nostrils. In obstinate bleeding from leech-bites a dossil of cotton wool may be impregnated with a saturated hot solution of alum and pressed upon the bleeding point. The same procedure may be adopted in severe hæmorrhage after tooth extraction, or alum in powder may be applied by means of soft, moist sponge, or a pledget of cotton wool, which should be firmly fixed upon the bleeding surface.

Alum is frequently used in hæmorrhage from the cervix uteri. Several ounces of a saturated solution may be injected into the vagina, the patient being in such a position as to keep the solution in contact with the cervix. Pledgets of cotton wool, soaked in a saturated solution of alum, may be applied to the bleeding surface.

In hæmoptysis solutions of alum, containing from one to five per cent., are employed in the form of spray. The inhalations are held to be most useful when the hæmorrhage is moderate, but recurs frequently at short intervals.

Liquor Ferri Chloridi.—The solution of chloride of iron is the most powerful styptic. It coagulates not only the blood which has escaped from vessels, but also that within the vessels with which it comes in contact. Even diluted with two or three parts of water, it condenses the tissues, contracts the blood vessels, especially arterioles and venules, and produces more or less irritation, often followed by inflammation.

Its action on the albumen of the blood is not instantaneous, from twenty to forty seconds elapsing before a firm coagulum results. If present in considerable excess, it gradually dissolves the coagulum.

Solution of chloride of iron is applicable in cases of hæmorrhage in which less irritating styptics, such as tannin and alum, are inefficient, and it may be employed in all accessible hæmorrhages from small vessels. In recent wounds, when other hæmostatics have failed to arrest the bleeding, the solution, undiluted or diluted with two or three parts of water, is frequently used. Before its application the bleeding surface should be thoroughly cleansed from blood and coagula, so that the styptic may come into immediate contact with the open vessels. A clean sponge, previously steeped in ice-water and squeezed out, should then be firmly pressed upon the bleeding surface, until a mass of cotton saturated with the iron solution, and well pressed between the fingers to remove the excess of the chloride, is ready for application. The cotton should be applied instantly after the removal of the sponge. Then another mass of cotton wool, moist but not wet with the iron, should be applied over the first and gently pressed upon it. If the bleeding ceases, dry cotton may be placed over the moist masses, and firmly fixed to the part by appropriate dressings. If, however, the flow of blood should still continue, the compresses should be removed and others applied in the same manner. It is important that the cotton compresses be only moist, not dripping wet, with the solution of chloride of iron, as an excess of the latter exerts a solvent action on the coagulum. As a rule, the compresses should not be removed before the third day. Then cold water should be gently injected into the masses of cotton, so that no force may be required for their removal.

In hæmorrhages from cavities, such as the nose, vagina, uterus, and rectum, the solution of chloride of iron, diluted with three or four parts of water, is usually ef-

fectual. Such a solution was used by Barnes and others to arrest post-partum hæmorrhage, being slowly and carefully injected into the cavity of the uterus. Breisky and some other German writers maintain that a very dilute solution, containing only sufficient chloride of iron to impart to the water a deep wine-yellow color, is equally effectual. In uterine hæmorrhage occurring at a late period after labor, a mixture of equal parts of water and solution of chloride of iron is sometimes applied to the cavity of the uterus by means of a pencil or a sponge.

A weak solution of chloride of iron has been given internally to arrest gastric and intestinal hæmorrhage. Some good may possibly follow in gastric hæmorrhage, if the bleeding occurs slowly from small vessels; but in intestinal hæmorrhage no reliance should be placed on styptics.

Good observers affirm that they have found inhalations of the spray of dilute solutions of chloride of iron, containing from one to five per cent., very efficient in severe hæmoptysis, after subcutaneous injections of ergotin had failed.

Liquor Ferri Subsulphatis.—This solution, commonly called Monsel's solution, is supposed to coagulate blood as speedily and firmly as the chloride of iron, and to be less irritating to the tissues. Whether it contracts blood-vessels has not been determined experimentally, but it probably is less active in this respect than the chloride.

In hæmorrhages from accessible parts it may be applied undiluted, or diluted with two or three parts of water, in the same manner as the solution of the chloride. It is generally preferred to the latter in bleeding from cavities, such as the nose, mouth, throat, and rectum.

Cotton steeped in solution of subsulphate of iron and then dried, is known as hæmostatic cotton. It is applied to bleeding surfaces, previously well cleansed, in a thick layer, and firmly supported by a compress and roller.

Dry subsulphate of iron, obtained by evaporating the solution, made into suppositories with cacao butter, is frequently employed to arrest hæmorrhage from the rectum and the cervix uteri.

Iodine.—In the form of tincture, iodine is used as a styptic in some kinds of uterine hæmorrhage. Some authors state that the best results may be obtained from a stronger solution, known as Churchill's tincture, consisting of seventy-five grains of iodine, ninety grains of iodide of potassium, and one ounce of alcohol. This preparation has been highly recommended for the arrest of metrorrhagia due to uterine fibroids and cancer of the cervix. It may be injected into the uterine cavity if necessary, after previous dilatation of the cervix, by means of a hard rubber syringe, the nozzle being pushed near to the neighborhood of the fundus. The injection should be made very slowly, and a mass of cotton should be placed at the os uteri to prevent the iodine, as it escapes from the cervix, from passing over the vaginal wall. The quantity which should be injected varies, but should never exceed one drachm. Sometimes the tincture is applied to the uterine cavity by means of a pledget of cotton wrapped around an applicator. Much weaker solutions of iodine have been successfully employed for the arrest of metrorrhagia.

Argenti Nitras.—Nitrate of silver coagulates albumen and strongly contracts blood-vessels. It is never used in ordinary hæmorrhages, but is very convenient for the arrest of obstinate bleeding from leech-bites, a pointed stick being gently pressed upon the bleeding point. *Samuel Nickles.*

SUDAMEN. An inflammatory affection of the skin, involving the closure of the sweat-ducts, with the formation of numbers of discrete, minute, clear vesicles, from the size of a pin-point to that of a pin-head, rising directly from the skin, with little or no congestive areola. The vesicles usually contain a clear acid fluid which is not sticky, and dries up without leaving any crust. The eruption usually occurs in the course of fevers or other severe general diseases. It was formerly supposed to be a substantive disease, and under the terms *suette miliaire*, *suette de Picardie*, etc., was even described as epidemic.

By many physicians the affection is supposed to be a form of that previously described in this work under the name of Miliaria. The distinction usually made is that, while in miliaria there is always a congestive base, in sudamen the vesicle rises from the unchanged surface of the skin. To this it may be added that miliaria is almost always connected with excessive sweating, in persons otherwise healthy, while sudamen is a concomitant of febrile or other exhausting disease. The treatment is the same as that of miliaria. *Arthur Van Harlingen.*

SUET (*Sevum*, U. S. Ph.; *Sevum Præparatum*, Br. Ph.; *Sebum Ovile*, Ph. G.; *Suif de Mouton*, Codex Med.; Mutton Suet, Mutton Tallow. The Codex also recognizes the similar product of the Ox, *Suif de Bœuf*, *Suif de Veau*, as well as the marrow, *Moelle de Bœuf*). The part of the animal taken for this preparation is the same that yields the hardest and best lard, or beef tallow, namely, the thick mass of fat lying along the loins and surrounding the kidneys. The whole tissue is suet, the fat melted out and purified is tallow.

The preparation is exceedingly simple, although not always well done. It consists in first cleaning the suet from connective tissue, vessels, blood, etc., then cutting it in small pieces and washing in cold water, or allowing it to soak for a few hours in water; then it is boiled with a little water until the tissue is broken up, strained, and poured away to cool; the last portion of water is then removed by prolonged, moderate heat, which should not be allowed to rise above the boiling point of water. In the laboratory the steam kettles offer the most perfect means of "trying out" lard and tallow.

Mutton suet has no medicinal properties not common also to the other animal fats, excepting greater hardness, a higher melting point, and perhaps superior keeping qualities to most of them. It consists of the usual glycerine fats, *stearin*, *palmitin*, *olein*, etc., with the former in excess, and the latter at a minimum. The pharmacopœial description is as follows: "A white, smooth, solid fat, nearly inodorous, gradually becoming rancid on exposure to air, having a bland taste, and a neutral reaction. Soluble in 44 parts of boiling alcohol, in about 60 parts of ether, and slowly soluble in 2 parts of benzin. From its solution in the latter, kept in a stoppered flask, it slowly separates in a crystalline form on standing. It melts between 45° and 50° C. (113° and 122° F.), and congeals between 37° and 40° C. (98° and 104° F.)." Suet forms about one-fourth of Mercurial Ointment and one-half of Tar Ointment. It is also an extensively used domestic cerate.

Allied Substances.—Numerous fats of domestic and wild animals are in common household estimation for one purpose or another, with very little real difference from each other except in odor and hardness. Goose, chicken, and skunk oils are extensively used in country families all over New England. Something more distinctive, and having peculiar claims to attention, are the preparations of grease obtained from the wool of sheep, and called by the commercial names of "Lanolin" and "Agnine, etc." The former of these was introduced as a patented article by Liebreich some five years ago. His process for preparing it is said to be as follows: "He takes the suds from the washings of wool in the mill, submits it to the action of a centrifugal machine which separates the soapy, oily suds from the dirt associated therewith, decomposes the suds by an acid, whereby the acid and the saponifying alkali unite, and the saponified wool-fat is separated, combined with about one hundred per cent. of water; this is thoroughly washed with cold water, then heated so as to separate the water and wool-fat, and again combined with a definite proportion of water, and lanolin is the result." Or the wool itself may be treated with alkaline water and the suds produced proceeded with as above; or the fat finally may be dissolved out with petroleum, benzin and obtained by evaporation, and mixed with a suitable proportion of water (*Therapeutic Gazette*).

Lanolin is a soft-solid, adhesive, ointment-like, fatty substance, of a light yellow color, a woolly odor, and slight oily taste; rubbed upon the skin it at first greases it, but soon it disappears by absorption, leaving the skin soft, smooth, and nearly clean; it mixes with its weight of water smoothly. It should be neutral in reaction, free from glycerine and ammonia, and should never become rancid. It contains a large amount of cholesterin. It is not in the least irritating. The miscibility with water, and ready absorption by the skin, make this substance of especial value in making a class of ointments which of late had fallen considerably, and deservedly, into disuse from their unreliability, viz., those containing active medicines used with the hope of their absorption; mixed with lanolin these substances are unquestionably absorbed, and iodide of potassium, mercury, aconite, atropine, morphine may be given in this way through the skin; as a simple protective also it equals the other fats. It is so sticky that, for convenience in using, it is better mixed with a third or half of some other fat (lard or tallow).

Agnine is the name given to another preparation from the same source, apparently unmixed with water; it is harder, darker, and less agreeable in color and odor than lanolin, to whose uses it is said to be adapted.

W. P. Bolles.

SUGAR (*Saccharum*, U. S. Ph.; *Saccharum Purificatum*, Br. Ph.; *Sucre de Canne*, Codex Med.); Cane Sugar, Saccharose, Sucrose, etc., $C_{12}H_{22}O_{11}$.

Common sugar is one of a group of soluble, sweet-tasting compounds formed by plants in the process of assimilation, or provided in their seeds, fruits, or other organs in storage for later consumption. This particular variety, although pretty widely diffused among plants, is in practice obtained from five or six only, where it is very abundant. These are:

Saccharum officinarum Linn.; Order, *Gramineæ*, the Sugar Cane, a large East Indian grass, whose solid stems are laden with it, furnishes most of the sugar of the world.

Beta vulgaris Linn.; Order, *Chenopodiaceæ*, the Sugar Beet, a South European plant, long cultivated for fodder, but utilized for sugar during the present century. It supplies half the sugar of the continent of Europe.

Acer saccharinum, Order, *Sapindaceæ*, the Sugar of Red Maple, yields the Maple Sugar of America.

Saguerus Rumphii Roxb. (*S. saccharifer* Bl.); Order, *Palmæ* and other Palms, supplies sugar, drink, and liquor in India.

Sorghum saccharatum Pers., another grass, is cultivated for sugar in China, and very slightly in the United States.

Sugar has been known from a very remote period in India, where the cane has been used as food from prehistoric times. It found its way into Europe about the beginning of the Christian era, probably as a natural exudation, like manna, from the wounded canes. Its preparation by extracting and boiling the juice, and its partial refinement, are developments of the first third of this era. At first sugar in Europe was expensive, a rarity, and only used as a medicine or luxury; its general use as a food here dates back only two or three hundred years. Even the last half century has witnessed an enormous extension of it.

PREPARATION.—The canes are cut when well grown, stripped of leaves, and crushed between strong iron cylinders which press out their sweet juice. This is immediately neutralized with a little milk of lime, to prevent decomposition of the sugar and souring, as well as to precipitate some of its impurities. It is then heated, the albuminous "scum" removed, and the clear juice boiled down until it will crystallize upon cooling, when crude sugar and its mother liquor (molasses) are the results. To this outline many details must be added to give an idea of modern sugar-making. The mill has been developed to give equable pressure whatever the thickness of the feed, and series of vacuum pans have, in most places, superseded the old open boilers; while some processes of purification or filtration have been put in use during the boiling at the mills. The raw or brown sugar produced in this way is then usually exported to northern countries—Europe and America—for refinement. This consists, with many variations and details, in redissolving the sugar, straining it, and precipitating impurities again, perhaps with lime; by boiling with blood-albumen and by filtration through long columns of animal charcoal; the clarified syrup is then condensed in vacuum boilers until it will crystallize on cooling; the sugar so formed is drained in moulds, or dried in centrifugal machines, and finally sold in loaves, lumps, fine crystals (granulated), or powder. The drainings from the sugar in this last crystallization, constitute the Sugar-house Syrups of the market.

The process of extracting sugar from the Beet consists in cleaning, grinding, and pressing the roots to obtain the juice, or, to get a cleaner product, in slicing them and subjecting them to a sort of repercolation process; this liquid is then heated with lime and injected with carbonic acid, which precipitate albuminoid and other impurities, and finally the lime itself is freed from its combination with the sugar. The clarified juice is then further filtered through animal charcoal, and finally evaporated as above.

From the Maple the sap is collected in the early spring by tapping the trees and attaching suitable receptacles; the sap is then simply boiled down in iron pots until it will become solid upon cooling, and is then run into pans.

There are several grades of imperfectly purified sugar sold for family use, as brown-, yellow-, coffee-sugar, etc., but none of them is suitable for medicinal or pharmaceutical uses; neither is the maple sugar.

Sugar scarcely needs a description. That of the market is practically pure—a little earthy residue, occasionally a little coloring matter, and perhaps a trace of one of its derivative sugars may be found, but often nothing; the most tempting adulteration is glucose, but this in crystallized or granulated sugars is rare. The Pharmacopœia gives the following tests of its purity: "Neither an aqueous nor an alcoholic solution of sugar, kept in large, well-closed, and completely filled bottles, should deposit a sediment on prolonged standing (abs. of insoluble salts, foreign matters, ultramarine, Prussian blue, etc.). If a portion of about one gram of sugar be dissolved in ten cubic centimetres of boiling water, then mixed with four or five drops of test solution of nitrate of silver,* and about two cubic centimetres of water of ammonia, and quickly heated until the liquid begins to boil, not more than a slight coloration, but no black precipitate, should appear in the liquid after standing at rest for five minutes (abs. of grape sugar and of more than a slight amount of invert sugar)." Sugar is soluble in half its weight of cold, in one-fifth of its weight of boiling, water, in one hundred and seventy-five parts of alcohol; not soluble in ether. It deviates polarized light to the right. It forms compounds with both alkalies and acids. It keeps perfectly in the air, and pretty well in concentrated solutions (syrups). In dilute solutions it is readily decomposed by several fungi, the commonest of which is the yeast plant, *Saccharomyces Cerevisiæ*, under whose influence alcohol and carbonic acid are produced. Acetic, lactic, and butyric acids are also formed from it by their specific ferments. By heat, diluted acids, and in other ways, cane sugar is separated into dextrose (grape sugar) and levulosan, or uncrystallizable sugar. Caramel is an empyreumatic product made by heating sugar until it becomes brown. It is used in coloring foods and liquors.

ACTION AND USE.—Sugar is at present a very important food, whose consumption is constantly increasing as its cost is becoming less, and is also a valuable preservative of other foods, as fruit; but it has no medicinal importance whatever, excepting the negative one of increasing acidity of the stomach in certain dyspeptic conditions, and of increasing the glycosuria and discomfort of diabetics. In pharmacy it has several applications, first as a preserver of some unstable chemicals, as iodide, suboxide, etc., of

* Five per cent. solution in water.

tron, and of fruit juices; secondly, as an agreeable vehicle, as in the syrups and troches; and, thirdly, as a pill covering.

PREPARATIONS.—Syrup, or simple syrup, as it was formerly called (*Syrupus*, U. S. Ph.), is a solution containing sixty-five per cent. of sugar in distilled water. The medicinal syrups are made either from this as a basis, or directly from sugar, or frequently from both. One of them, Syrup of Lime (*Syrupus Calcis*, U. S. Ph.), is a five per cent. solution of lime in combination with some of the sugar, which in this syrup is only thirty per cent. of the whole. All the Troches (*Trochisci*), contain sugar as their principal basis, excepting the Troches of Cubeb, which contain but a trifling amount. Both the officinal confections are made with it. Besides these classes of preparations, it is present as a flavor in many others, as Elixir of Orange, Sweet Tincture of Rhubarb, etc.

ALLIED SUBSTANCES.—If the derivatives of sugar and its natural varieties were to be included here, the list would be very long. The cane itself, when immature, contains a good deal of uncrystallizable sugar; molasses consists mostly of it, which is not exactly like the typical sugar. It is also easily decomposed, as seen above, into two sugars, neither of which is exactly like itself. Many fruits are sweet by reason of their glucose or grape sugar, others because of the presence of an uncrystallizable compound generally called fructose. Some of the glucosides in their decomposition yield sugars of peculiar properties. The sugar developed in malt is different from that of the cane, and called maltose. The following have some commercial importance and relation to cane sugar: *Lactose*, see Milk, Sugar of; *Glucose* (starch sugar, etc.), an artificial sugar prepared on a very large scale, and used in the arts and especially in cheap confectionery; it occurs as a syrup, commercially called "glucose," and as a yellowish-white crystalline cake or powder, "Starch Sugar." It is very much less sweet than sugar, and has, besides, a mawkish taste *Manna*, *Liquorice*, *Honey*, and *Glycerine* resemble sugar in taste and in some of their applications.

Saccharin.—This interesting substance was first produced from toluene, a coal-tar compound, in 1879, by Dr. C. Fohlberg, of New York. Its chemical name is given as anhydro-ortho-sulphamin-benzoic acid. It is a white, crystalline powder, soluble in something more than two hundred parts of cold water, more freely in hot water, and abundantly in alcohol and ether. It has no chemical relation to the sugars whatever, and was named saccharin, a word already applied to one of the sugars, solely on account of its intensely sweet taste, which is said to be two hundred and eighty times that of sugar; one part in seventy thousand of water is distinctly tasted. Saccharin appears to be a stable compound of no action whatever upon the body, five grams a day producing no symptoms, the use of which by diabetics and dyspeptics may satisfy that craving for sweet which makes their diet so unsatisfactory; half a grain is enough to sweeten a cup of coffee, half a dozen grains for a whole day's food. It is eliminated by the urine unchanged.

W. P. Bolles.

SUICIDE. The term suicide, to express the act of self-destruction, was probably first employed by Desfontaines in the last century. It is derived from the Latin words *sui* (self), and *cædere* (to kill). Synonyms: Fr., *Suicide;* Ger., *Selbstmord;* It., *Suicidio;* Legal, *Felo de se.* Other rarely employed terms are: Gr., αὐτοχειρία; and Lat., *Propriicidium.*

Suicide is a voluntary human act of self-destruction, which, when undertaken with "malice aforethought," is a crime under the law; and only under these circumstances should it be called self-murder, and be punishable.

It is claimed by some writers that the act is always due to some disorder of the mind at the moment of its accomplishment.

HISTORY.—From the earliest times of which we have record the custom of self-destruction has existed to a greater or less degree, and it would appear that the peoples of antiquity were so taught by their religion that they could look upon the act as logical, and perform it with stoicism.

The religion of Brahma justifies suicide, and looks upon it, under certain conditions, as an honorable and praiseworthy act, which is often solemnized in a public manner. Fanatics in India, who believe in the transmigration of souls, seek an improvement in their condition and a freedom from present ills by courting death. The Brahmins have in a great measure given up their terrible custom of prostrating themselves before the car of their gigantic idol Juggernaut, to be crushed to death. Still they occasionally do it, and the women throw themselves upon the funeral pyres of their husbands.

Although held in honor among the people of the Orient, it was always rare in Persia, and is an exceptional occurrence among the Turks. The teachings of the Koran are opposed to it. Mahomet forbade it, and inculcated a spirit of patience in adversity. Here, too, the belief in fatalism probably exercised a marked influence, and the people were not given to philosophic thought, as were those of Greece, where many great men have sought death at their own hands.

When circumstances warranted the act, it was considered, in ancient Greece, a virtue for men to destroy themselves, thus escaping human ills, and, as they supposed, ameliorating their condition.

According to Legoyt,[1] Strabo relates as an historical fact that the inhabitants of the Isle of Ceos, in the Grecian Archipelago, poisoned themselves after reaching the age of sixty, so that the younger could have greater abundance; and Montaigne says that the senate of Marseilles, which then belonged to Greece, placed poison at the disposition of those who wished to commit suicide, when their motives were approved of.

The Hebrews, it would appear, scarcely knew suicide, and few cases are recorded. The Bible gives accounts of the self-destruction of Samson, Eleazar, Saul, Judas, and others.

The Celts were taught the immortality of the soul and their divine origin, still, suicide for the old and infirm was encouraged.

At Rome we find many noted suicides recorded, including that of Junius Brutus, and under the reign of Tiberius they appear to have increased in frequency. From the fifth to the twelfth centuries suicide almost wholly disappeared, but in the next century revolutionary ideas prevailed, and the previous influence of the Christian religion was so far lost that all classes of society suffered from a revival of suicide. Jews now resorted to it freely as a means of escape from hardships, and to avoid disloyalty to their faith.

A decided increase is noted from the beginning of the sixteenth century, due to a disregard for religion and a revival of customs of antiquity.

In China and Japan men of honor have long resorted to self-inflicted death.

In Africa it was not rare for individuals and whole bodies of men to commit suicide, and Carthaginian generals often destroyed themselves after defeat.

The increase of suicide in civilized countries during the present century is shown by carefully gathered statistics, and conceded by most writers.

STATISTICS of suicide began to be systematically collected and studied only in the present century, official statistics being published in several European countries during the first twenty years of the century.

The statistics here made use of are, for the most part, drawn from the excellent work of Morselli.[2]

In 1840, Farr, the director of English statistics, calculated that the average annual number of suicides in England and Wales was 62.8 per million inhabitants. I have calculated from Morselli's table, covering the years from 1830 to 1876, and made up from the work of various observers, and find the proportion to be 66.6 per million.

The number of suicides is probably much greater than is indicated by official reports, and this may vary in different countries.

The following table shows the proportion of deaths by suicide in various countries in 1882 :

Countries.	Estimated population.	Deaths by suicide.	Per 1,000,000 inhabitants.
Austria	22,316,567	3,530	158
Baden	1,596,206	283	177
Bavaria	5,389,732	724	134
Belgium	5,655,197	595	105
Denmark	2,008,100	513	255
France	37,769,000	7,213	191
Italy	28,596,512	1,389	49
Prussia	27,796,189	5,312	191
Saxony	3,040,000	1,128	**371**
Sweden	4,579,115	482	105
England and Wales	26,413,861	1,965	74
Ireland	5,097,853	105	21
Scotland	3,785,400	167	44

The German and Scandinavian races furnish the largest numbers. Only a few States in this country furnish accurate information, and there are no statistics for the whole of the United States.

The following table shows the number of deaths by suicide in Massachusetts, Rhode Island, and Connecticut in the years named.

Years.	Massachusetts.		Rhode Island.		Connecticut.	
	Total.	Per 1,000,000 inhabitants.	Total.	Per 1,000,000 inhabitants.	Total.	Per 1,000,000 inhabitants.
1870	91	62	27	124	....	....
1871	122	82	19	84	....	....
1872	117	76	18	77	....	....
1873	117	74	8	33	....	....
1874	115	71	18	72	....	....
1875	159	96	26	101	....	....
1876	119	72	18	60	49	[illegible]
1877	163	98	[illegible]	83	52	84
1878	126	76	21	78	55	83
1879	161	94	13	48	58	95
1880	133	75	10	36	48	77
1881	165	88	23	82	69	109
1882	162	88	31	109	65	101
1883	167	89	25	....	....	....
1884	184	96	85	....	....	....

The population is here calculated from the average annual increase since 1880.

In an editorial, which appeared in the *Medical Record* of August 14, 1880, it is stated that 60,000 persons kill themselves annually in Europe, and assuming that the same ratio exists here, nearly 10,000 suicides would occur in America.

Dr. John Lee,[3] of Philadelphia, has found that during the period from December 31, 1871, to January 1, 1881, there were fifty-three suicides in each thousand coroner's inquests held in the city of Philadelphia. Out of the 636 cases recorded, 444 were married persons, 24 were minors, and the greatest number occurred between the ages of thirty-five and fifty.

In statistical tables prepared by Dr. John T. Nagle,[4] of New York, covering a period of eleven years, ending December 31, 1880, it is shown that 1,193 males and 328 females committed suicide. Between the ages of ten and fifteen there were 15 ; between thirty-five and forty the greatest number was found, viz., 212 ; and between eighty-five and ninety there was only 1 ; 430 were single, 759 were married, and 137 were widowed. The means employed by the greatest number was poisoning, which gave 503. Those dying from firearm wounds numbered 397 ; 239 died by hanging ; 175 by cut and stab wounds ; 101 by drowning ; and 82 by leaps from heights. Of German birth there were 627 ; of Irish, 213 ; of English, 82 ; and 368 were native born, the remainder being distributed among natives of twenty-two different countries.

One table shows that the suicides for the year 1880 were :

New York City	152,	an average of	12.59	per	100,000	inhabitants.
Philadelphia	68	" "	8.03	"	"	"
Richmond	1	" "	1.54	"	"	"
Washington	18	" "	10.13	"	"	"
San Francisco	88	" "	37.65	"	"	"
Boston	40	" "	11.03	"	"	"

The same year we find in

Berlin	308,	an average of	27.44	per	100,000	inhabitants;
Vienna	230	" "	31.67	"	"	"
London	352	" "	9.34	"	"	"
Leipzig	84	" "	57.04	"	"	"

In the reports of the New York Board of Health for 1886, I find that 223 deaths from suicide are recorded ; 58 native born, and 165 of foreign birth, 98 of whom were Germans. Firearms were used 62 times ; the rope, 37 ; cutting instruments, 29 ; drowning caused 16 deaths ; Paris green, 11 ; "Rough on Rats," 8 ; and leaps from heights, 15. As regards sex, 172 were males and 51 females. The period between thirty and thirty-five years of age gave the greatest number (31 cases).

During the year ending September 30, 1887, I find 225 suicidal deaths ; 175 males and 50 females. The whole number, and the proportion of the sexes, conforming closely to the statistics for 1886. Paris green was employed in 11 cases, arsenic in 8, and rat poison ("Rough on Rats") in 12.

According to the London *Lancet*, the number of suicides in France during 1876 was 5,617. Of these 4,435 were men.

Morselli believes in a law of continual increase, and shows by a table that the increase per cent., from 1827 to 1852, was from 100 to 238.

It is shown by one of his tables that Saxony, which furnishes the largest number of suicides, has suffered an increase from 158 per million inhabitants in 1836–40, to 391 per million in 1877.

Another table prepared from the statistics of Italy, from 1864 to 1877, shows an increase from 29.2 to 40.6 per million.

From these and other data, the following law is formulated :

"In the aggregate of the civilized states of Europe and America, the frequency of suicide shows a growing and uniform increase, so that generally, voluntary death since the beginning of the century has increased, and goes on increasing more rapidly than the geometrical augmentation of the population and of the general mortality."

In the combined central and southwestern states and provinces belonging to Prussia the proportion of 150 suicides in the million is given. Morselli says :

"The synthetic and most certain law which springs out of these facts, is that in the centre of Europe, from the northeast of France to the eastern borders of Germany, a *suicidigenous* area exists, where suicide reaches the maximum of its intensity, and around which it takes a decreasing ratio to the limits of the northern and southern states."[5]

Nature.—The question of the nature of the act of self-destruction is a difficult, and a delicate one withal, to decide, but its great importance calls for much careful attention. Morselli says suicide is a social fact, and its nature "may now be reckoned among the most certain and valuable discoveries of experimental psychology ;" and further on, characterizes it as "an effect of the struggling for existence and of human selection, which works according to the laws of evolution among civilized people." But the question arises, is a given suicide, at the moment the act is committed, in the full and free possession of his faculties, and should he be held responsible for his movements ? If the act be always due to a morbid condition of mind (as claimed by Dr. Liebman, in a paper read before the Medical and Chirurgical Faculty of Maryland, April, 1881), it should not be punishable as a crime ; nor would, in this event, the punishment carry with it the intended restraining influence upon other would-be suicides. The mind which could conceive and plan so foul a deed would not, in all likelihood, be influenced by the thought of legal punishment in case of an unsuccessful attempt.

Insanity is probably present in the vast majority of suicidal attempts, and the number of those who act calmly and in the possession of their faculties must be much smaller than is generally supposed. Many obscure cases are difficult to explain on any other theory. There is a

want of motive. The surroundings and station in life of the suicide are the best, and so far as can be learned, the social, financial, domestic, and other relations are only such as would be conducive to life and happiness. Such cases are more common in so-called epidemics of suicide. If the attempt has not resulted in death, evidences of insanity often soon appear, and make it clear that mental irresponsibility existed at the time.

In other cases insanity may have been previously known or suspected from conditions present, either immediately preceding the act or at some more remote period, and still no decided symptoms may have shown themselves until after an attempt at suicide.

An hereditary mental defect may have been known to exist, the person regarded as eccentric, and the attempt not unlooked for.

Organic disease, excesses, venery, onanism, etc., may have been the cause of a mental aberration whose first outward sign has been the suicidal attempt.

Hammond says:[6] "Closely allied to emotional homicidal impulse is that form of mental derangement which consists in an *emotional impulse to the perpetration of suicide.* The conditions may coexist. In some cases the contemplation of the act is attended with feelings of pleasure. He is neither governed by delusions nor by logical reasons. He is actuated by a passion which it is pleasant for him to gratify. When the impulse has passed, he looks back upon it with horror, and shuddering at the escape he has made, perhaps seeks medical advice."

Automatic suicide, or suicide by impulse, is closely allied to that of the insane, and like it, occurs without apparent cause. The sight of a weapon, the finding of one's self upon a height or by the river's side, or favorably situated for the accomplishment of the act, being sufficient for the attempt. In non-success the circumstances of the act are more or less confused in the suicide's mind, and the only safety for those thus impelled is to hasten from the scene. Some persons appearing to be conscious of this outward influence, avoid suggestive situations, and feeling themselves powerless to resist, ask that precautions be taken to prevent the act.

Suicide by suggestion is well illustrated in a personal experience of Sir Charles Bell, when surgeon of the Middlesex Hospital, which is related by Wynter.[7]

While being shaved, he told his barber of an operation he had just performed on a man who had made an unsuccessful attempt to cut his throat, and explained the anatomical reasons for the failure. The barber, excusing himself, went into an adjoining room, and was found a few moments later with his throat cut in the proper anatomical situation to assure success.

Epidemic suicide, due to a neuropathic state of the system of those living under the same influences, is well known to neurologists, and many instances have been observed. An epidemic among the women of Miletus is recorded, at a time when the men were away at war, which reached great proportions and was checked by a decree, that the naked bodies of those who killed themselves should be exposed in public with a rope about the neck. In Mexico and Peru the inhabitants killed themselves in great numbers, it is said, after the invasion by Spain. Mansfeld had an epidemic in 1697, according to Sydenham. There was one at Versailles in 1793, and one occurred at Rouen in 1806, and at Stuttgart in 1811.

Some years ago five inmates of the Hôtel des Invalides, in Paris, hanged themselves upon the same crossbar within a fortnight.

Double and *multiple* suicides are occasionally recorded. The former usually consisting in the simultaneous death of man and wife, or two lovers or friends; the latter in the concordance of suicide of bodies of men, such as is said to have occurred in China among the philosophers of the Confucius School, when deprived of their books by the order of the emperor Chi-Koang-Ti.

Feigned Suicide.—Although the term is not a strictly proper one, it applies to those cases occasionally met with in which, to excite sympathy, secure desired ends, afflict friends, or for some other reason, a person makes it appear that he has made an attempt upon his own life.

Child suicide requires special notice, as it is not uncommon to find quite young children, even as young as five years, taking their lives for trifling cause, following impulse and sentiment without having the restraining influence of mature judgment, and the power of comparison and thought for anything beyond the present.

By nature children are sensitive to slights and injustice, easily depressed, fretful under restraint, and at times revengeful. They have vivid imaginations, are quick to imitate, but are defective in the power to reflect and form just conclusions. The sense of responsibility is wanting, so that no sooner is the act conceived than it is put into execution.

The belief of Durand-Fardel,[8] that the act of self-destruction is usually accomplished with much self-possession, and after reflexion, cannot apply to suicides in childhood (see, also, under Age).

Suicide following homicide is not very uncommon, but the subject is almost always melancholic. Esquirol tells of a Belgian woman who threw her four children into a well and jumped in after them. Both sexes include their children in the death they give themselves, but women would appear more inclined to this than men. In rare cases both parents conspire to kill their children and then themselves; such a case is related by Esquirol, and one has recently occurred in Paris.

Causes of Suicide.—In former times, and indeed at the present day in some countries, as we have seen, whole masses of people, as well as individuals, under the influence of their religious or philosophic beliefs, and following the customs of their forefathers for generations, have in great numbers become the subjects of self-destruction. No such custom is to be found to-day in any civilized country, but efforts to do away with it in India have failed, and we must put down fanaticism as one cause of many self-inflicted deaths. No encouragement is given to the act in enlightened lands, but, on the contrary, all laws, both human and divine, are strict in its forbiddence. Still, suicides have been shown by careful students of the subject to be on the increase, and we naturally inquire what are the causes which contribute to this state of affairs, and why do men take their own lives at all.

The causes are twofold: A subjective condition may exist which predisposes the individual to the act, or his environment may be such as to produce an objective state favorable to suicide. The pathological or other subjective condition may coexist with the surroundings which furnish the determining cause, or the one or the other may be wanting.

Predisposing causes to suicide are quite numerous, but heredity is one of the most important. The transmission of a suicidal tendency is an established fact of which many instances are known to alienists, and which forms a familiar phase of the practice of the family physician.

This transmitted tendency may lie dormant, or make its presence suspected by the development of mental disease; or the suicide may have been looked upon for years as one about whom there was "something strange," without any actual disease or decided symptoms of nerve or mental trouble being apparent.

The offspring of a suicidal parent appears to inherit a system favorable to the development of nervous affections leading to self-destruction, and a decided tendency appears to exist to commit the act at about the same age at which the parent died, and to use the same means; showing that the hereditary disposition is attended with a certain uniformity of action.

Education would appear to predispose to suicide, for it has been conclusively shown that more attempts occur in centres of civilization, among the best educated classes, and in cities where, through the press, pulpit, and stage, as well as through educational institutions proper, the masses of the people are better informed than those in the country, and, as a rule, have more active minds; but in whom the conditions of life are more apt to favor a spirit of discontent. Among savages suicide is comparatively rare.

Occupation appears to have a predisposing influence. Thus the trades in which the greatest number of suicides occur are shown to be those of tailors, seamstresses, laundresses, jewelers, carpenters, cooks, etc. The hardships of life attending many of these occupations may account for the number of deaths.

Wine merchants and inn-keepers make large contributions to the number of suicides, because their occupation tends to induce excess in the use of alcohol.

The liberal professions furnish about one-fifth of the total number of suicides; physicians, chemists, and druggists give a high percentage, and their occupations may be said to predispose to it by bringing them into such constant and intimate relations with poisons.

The stringency of military discipline in Germany, France, and Austria has been advanced as a reason for the high death-rate from suicide in these countries.

Morselli finds the greatest number of suicides among (1) literary and scientific men, or brain-workers generally, professors, teachers, etc.; (2) the military; (3) workers in the trades.

According to Legoyt (1856-1860), the middle classes and outcasts furnish the greatest number in France, and the same is found by Block to hold true (p. 251).

The condition of life has its influence as well, and those living solitary lives, as widowers, bachelors, divorced women, etc., are more prone to the act.

Climate and temperature in many instances undoubtedly contribute their share, but the attempts to regard them as the main cause of a high percentage of suicides in some countries have not been eminently successful. Thus the cold, rain, and fog of England have, by various writers, been regarded as conducive to self-destruction. Thus Montesquieu said, "England is the classic land of suicide;" but in Wynter we read ("The Borderland of Insanity," 1875) "Paris is the headquarters of self-destruction."

Putting aside the compliments that may be passed between these two countries, we must remember that the Esquimaux and Falkland Islanders, whose climate is incomparably more severe than either, do not kill themselves.

The influence of climate is, on the whole, not marked, but excessive heat has been known to drive men to frenzy and self-destruction. Long since it was pointed out that the hot and dry wind of the African sirocco caused delirium, madness, and many suicides.

Seasons.—In most countries the maximum of suicides is reached in May and June, when nature would seem to be most conducive to life. In Saxony and Bavaria, however, July is the favorite month.

Authorities agree that insanity increases in the summer time, and this may explain, as Wagner thought, the greater number of suicides.

Sex.—In a general way, the average of female suicides for the United States is given as from fifteen to thirty per cent. of the whole number. Liebman says three men kill themselves to every woman.

The proportion is given for Germany as under, and for England as over, twenty per cent. As accounting for this excess of male suicides it has been advanced that women have less energy, less resolution, are more governed by religious teachings, etc.

Age.—Considerable regularity is shown, in each country, in the number of suicides from year to year. From Ogle's table, as well as from those of Morselli, it is seen that, from the tenth year on, the number of cases rises steadily to between the ages of fifty-five and sixty-five years; remains almost stationary to about seventy-five, and then decreases rapidly. It is rare before fifteen, but excepting the very young, it is common to all periods of life.

The period from the twentieth to the fiftieth year has the most instances, for it is then that men pass through the most serious portion of their lives. It is then they are engaged in the battle for existence, require more comforts of life, and have most care and responsibility.

According to Ogle, one out of every 119 men who reach the age of twenty, ultimately dies by his own hand, and one out of every 312 women who have reached the age of fifteen.

Attempts upon their own lives have been made by children at as early an age as five years. Durand-Fardel found one under five, and two between eight and nine. Out of 25,760 suicides in France occurring from 1835 to 1844, he found 192 to be in persons under the age of sixteen.

According to the census of 1880, Hammond[9] says there were in the United States, during the preceding ten years, 2 suicides in children between five and ten years of age, 12 between ten and fifteen, and 66 between fifteen and twenty. He says that Collineau[10] relates the case of a boy ten years of age, who, "to make his parents angry," hanged himself on being sent back to school.

Winslow[11] reports several cases at an early age, and quotes Casper to the effect that in Berlin, from 1812 to 1821, 31 children, twelve years of age and under, committed suicide for trifling cause. Many cases at this early age appear to be similar to the emotional susceptibility of adult life.

Suicide is an act which springs from a brain constantly influenced by conditions present within the body, as well as by those of the external world, many of which we have considered as predisposing causes. We will now turn our attention to some of the internal and

Determining Causes.—Insanity with suicidal tendency is quite a common form of mental disease. I shall not enter upon a consideration of the various forms of insanity in which this tendency is present. We may find it as a monomania, or associated with a homicidal mania.

It is often by suicide that the melancholic rids himself of his imaginary woes, and the maniac escapes from the imaginary foes with which his hallucinations surround him.

There are those who claim that the act of suicide is of itself an evidence of insanity. In the maniac there is no planning, and no precautions are taken; violence is characteristic of the act, and it is as a rule accomplished quickly. Should it fail, there is a knowledge and recollection of the details. Death may accidentally result from the attempts of the maniac to escape from hallucinations, or in his efforts to free himself from restraint. This should not, properly speaking, be termed suicide, for although it is self-destruction, there is no intention or motive, and the term, as commonly used, implies a purpose.

In some insane persons there is an ever-present hallucination attended with a morbid sadness, and the act of suicide is deliberately planned and, with much precaution and calmness, carried into execution; or, if not at once successful, it will be persisted in until it is.

There is a form of anxious melancholy in which, without any cause either real or imagined, there is, as it were, an instinctive but violent desire to die; so strong, indeed, is it, that no will-power seems capable of overcoming it. The previous anxiety is lost when all preparations are made and the desired end appears near, and this sudden change to cheerfulness may give friends and attendants the cue to watch for the attempt.

As a rule, determined and deliberate attempts at suicide, with details carefully planned, indicate an unsound mind. When the attempt has failed to cause death, it is often found that insanity soon appears. In other cases the attempt itself relieves the condition which caused it, and death is no longer desired.

The flow of blood from a razor wound, Hammond says, may relieve the cerebral congestion present. In the same way, a plunge into the cold water may result in bringing the would-be suicide to a realizing sense of his desire for life rather than for death.

Others, to assure success, may tie their own hands and feet together before making the plunge, and may even attach weights to themselves, as in the recent case of a young actor who, before plunging into the Charles River, in Boston, put on a heavy coat of mail; and of a man who jumped from a Brooklyn ferryboat with lead-pipe wound round and round the body. The possible occur-

rence of such cases must be remembered in medico-legal and coroner's investigations, and not be mistaken for cases of murder. Financial ruin, famine, and pestilence following in the train of wars, etc., have often resulted in great numbers of suicides, the nervous system being over-excited.

Disease, as an inciting cause of the suicidal act, is not uncommon. The body, worn out with suffering, at last affects the mind, or the patient, believing his disease incurable, prefers to make an end of all his woes, and "fly to others which we know not of."

Statistics for Italy and France show that those affected with pellagra furnish a large percentage of suicides. Other diseases in which suicide appears to be common are those of the digestive organs, liver, etc., cancer, urinary diseases, phthisis, loss of sight, and chronic affections generally; after castration it appears also to be frequent. Suicides through physical suffering attain their maximum in the educated and cultivated classes.

Financial troubles cause the highest percentage among the working-classes, though self-destruction is often seen after reverses of fortune, losses in gambling, and financial embarrassment in the wealthy.

Alcohol is a potent cause of self-inflicted death; drunkenness, poverty, and laziness going hand in hand.

Passions.—Love, betrayed or disappointed, and jealousy are found to be a fruitful cause of suicide among students, soldiers, schoolmistresses, and servants. Explosions of rage and anger are apt to gradually increase and overcome the will-power to resist, until trivial circumstances will occasion violent outbursts, and may lead to violent acts against one's self. Hate, pride, shame, and revenge may all lead to suicide.

Other determining causes often found are domestic troubles, remorse, dishonor (as in women pregnant out of marriage), poverty, misfortune, grief, pain, and disappointment.

Occasionally regret is experienced before the act has been fully accomplished.

METHOD.—The method of securing death, and the place or scene of its execution, are influenced by the surroundings of the individual and the natural facilities afforded; but the supposition advanced by Esquirol, that the occupation governed the choice of instrument, is not always borne out by statistics. Still it is found that the choice of the soldier falls, as it in theory naturally would, upon firearms. Butchers, barbers, and shoemakers resort mostly to the knife. The favorite method varies in different countries, and although in a given locality or city the prevailing custom may change from time to time, there is a pretty constant preference for one fixed form from year to year. De Guerry[12] was the first to show a regularity in the method employed.

The rope appears to be the most common choice, second comes the water, firearms third, cutting instruments fourth, then follow jumping from a height, taking of poisons, inhalation of deadly fumes, etc.

There are two factors which, as a rule, influence the choice of the means, viz., certainty and quickness of action. Women are not so apt as men to make choice of a painless method.

There is also a difference in the means employed by women from those resorted to by men.

In Italy, for example, the men shoot themselves, and women resort to the water when weary of life; while in Prussia over half the suicides die by hanging, and women surpass the men in their tendency to kill themselves by the knife.

Poison, as a choice, appears to be increasing in favor in this country, and to be on the decline in France; in fact, the favor it receives among Anglo-Saxon suicides is shown to reach 40.8 per cent., including this country. Out of 148 cases of suicide occurring in New York in the year 1876, poison was used in 31.7 per cent.; firearms in 33.1; hanging gave 13.5; cutting wounds, 10.8; drowning, 6.8; falls from height, 3.4, and other means 0.7. Thus showing that poison and firearms were the choice, each in about one-third of the cases. This predilection on the part of the English and Irish for poisons is further shown by the following table, taken from Morselli, and giving the suicides among foreigners in New York for the year 1876.

Per 100.	English.	French.	Germans.	Irish.
Poisoning	46.1	25.0	28.9	52.4
Hanging	....	12.5	17.4	4.8
Asphyxia and drowning	....	....	5.7	9.6
Gunshot wounds	15.4	50.0	35 0	4.8
Cutting and stabbing	30.8	....	7.2	9.5
Falls from height	7.7	12.5	5.8	18.9
Total	100.0	100 0	100.0	100.0

Of the 39 cases of suicide which I have found reported in the daily newspapers of this city during the past fifty days, the greatest number (12) was by shooting, and the next highest (7) by taking poison. The poison chosen is usually the one easily obtained and of known efficacy.

In England the order of choice is prussic acid, cyanide of potassium, laudanum, oxalic acid, arsenic, strychnine, vermin killer, oil of bitter almonds.

In New York a vermin poison known as Rough on Rats, and supposed to contain arsenic, has been so much employed of late that the authorities have been asked to place restrictions upon its sale.

Drowning as a means decreases as the north is approached; the colder the water, the less its attractions.

Devergie found that in Paris, from 1827 to 1836, drowning, together with asphyxia by charcoal fumes, held the second place, but in 1851 Trébuchet placed asphyxia at the head of the list. This latter mode of death has spread rapidly over Europe and increased in fashion in Paris. The reasons for this are that it affords the most painless and agreeable form of death, and, strange as it may appear, man's vanity extends beyond the gates of death, and the suicide desires the body to present a good appearance after the breath has left it, and knows that there is usually no disfigurement from charcoal fumes.

Only the other day, the papers contained an account of a "wholesale charcoaling," in which a father, mother, and two children sought death in this way, preferring this mode of death to starvation. When heredity is a factor in the case, the method of exit from the world is apt to be the same as that employed by the ancestor.

Winslow says that one manner of death having been conceived, the man bent on suicide will wait a long time until he can carry out his particular plans. We, however, often see a man who has failed in one way take the first opportunity to secure death in another. Maniacs are most apt to throw themselves from a height, and it is often difficult to say whether one who has fallen from a window did so in simply making an attempt to escape imaginary enemies, mistaking the window for a door, or possibly walked out without any knowledge of the act, or was conscious of the attempt. Some inflict wounds upon themselves, or severely injure the head by pounding it against the wall, impelled by their pains to seek this means of gaining relief. Melancholics often hear a voice urging them to take their lives, and this "voice" at times suggests the means.

Place.—Much ceremony attends the act in some individuals, and publicity is sought. This is often done when revenge is intended. Usually, however, suicides occur in privacy, and it is not uncommon for a man to retire to a concealed and unfrequented spot to carry out his object.

Particular places may become, as it were, fashionable for a time, in the suicidal world. Thus, one year, in Paris, the Arc de Triomphe, another Notre Dame steeple, and another one of the bridges, will be the favorite leap. The Milan Cathedral, St. Peter's at Rome, and the Campanile at Florence, have all in turn had their epidemics, so to speak.

Esquirol[13] relates a very remarkable method which was employed in a case reported by Dr. Ruggieri,[14] an Italian, which shows what an amount of self-inflicted torture will be endured. A shoemaker in Naples, who had the year before castrated himself and thrown the geni-

tals from the window, after making a good recovery, conceived the idea that God had commanded him to suffer on the cross. He passed two years in perfecting his plans, which were so well carried out that one morning he was found with hands and feet securely nailed to a cross, with a stab wound in the left side, hanging out of his bedroom window. He had constructed the cross and attached it by ropes in such a way that after crucifying himself he could, by motions of the body, cause it to slip from the window. When rescued he was delirious, and though recovering from his wounds, he exhausted himself by fasting and died.

A novel method has just been introduced in this country by an anarchist, of exploding a dynamite cartridge in the mouth, bearing out Esquirol's claim, that the instrument chosen was apt to be the one which the suicide used professionally.

Time.—The time of day most favorable to acts of self-destruction appears to be between the hours of six and twelve in the morning. This preference for the early part of the day extends to the other divisions of time, for it has been found that more suicides occur in the fore-part of the week and the first half of the month than in the latter parts.

SYMPTOMS.—It is questionable whether we can say that there are any actual symptoms by which an act of suicide can be predicted. In insanity, and especially in melancholia, an attempt must always be watched for.

In some cases a man, who has been previously healthy, will complain of pain in the epigastrium, of heaviness in the head, will become quiet, listless, lose all ambition, refuse to work or attend to his usual vocations; the habits are changed, and intoxication may be indulged in. There may be scarcely any other symptoms until he tries to cut the thread of life. Weariness of life is often complained of, but Esquirol says he has never seen any attempt because of this *tædium vitæ* alone.

Some individuals predict that they will some day kill themselves and eventually do, but as a rule the one who threatens the act rarely commits it.

In some cases it may be discovered that preparations are being made for death, associated with a sadness of expression and an uneasiness of action. In melancholia the opposite condition may prevail just before the attempt, when all the plans are laid. The skin of suicides has been said to assume a yellow tinge and the features to become shrivelled, giving a changed appearance at the same time that a change is noticed in the actions.

Anæsthesia is a marked symptom at the actual moment of the attempt in many cases, and it is said that after the skin is cut the pain in cutting the throat is not at all severe. This accounts for the little complaint or appearance of pain in cases which, it would appear, must have been attended with torture.

DIAGNOSIS is important in a medico-legal sense, as we have seen that few signs or symptoms of value precede the act. A knowledge of previous attempts will aid us, and at times a hint may be given by some word of the individual, or by an ante-mortem letter.

If the attempt has failed the fact may be acknowledged; if death has resulted writings are to be looked for. The body is to be examined for lesions, especially in the vital regions. The direction of bullet and penetrating stab wounds is to be carefully noted, and the existence or absence of powder marks upon the skin, and wadding, pieces of clothing, etc., within the wound. If death has resulted from a sharp weapon, signs of violence must be looked for upon the body and in its surroundings. The employment of a razor, although favoring a theory of suicide, is not to be regarded as conclusive, because in this country it is quite a favorite weapon with the negro race. If the razor can be shown to belong to the individual, the suicide theory is strengthened.

If poison has been taken, a bottle or paper which has contained it may be discovered near the scene. Though most men found hanging are suicides, the possibilities of lynching and of hanging a dead body to hide a crime must be remembered. In bodies found in the water, great care must be exercised in giving true significance to wounds, and determining whether they were inflicted before death. The fact that the limbs are tied has not great weight, for the suicide might have thought thus to assure success, and even have attached weights to the body.

Pathological lesions found on autopsy shed but little light on the subject of suicide.

PROPHYLAXIS.—Cannot something be done, we instinctively ask, to prevent so great a number of human beings from committing so heinous an act? Something at least to prevent the ever-constant increase? The solution of the problem must lie largely in the better care of the insane, and earlier and more scientific treatment of mental diseases. Hospitals properly equipped for the treatment, supervision, and restraint of the mentally weak and infirm, and the disappearance of the popular prejudice against insane asylums, will do much to decrease the number of suicides in this large class.

Legislation.—In epidemic suicide and in alarming increase of the act, it has been found necessary to enforce stringent laws against the bodies, property, and families of the suicide at various periods of the world's history, and at times with some apparent success.

Laws were established in regard to suicide at a very early day. Zeno's motto, which was such a favorite phrase of the Stoics, "*Mori licet cui vivere non placet,*" was found not to have an application to the individual whose act caused injury to others and loss to the state. It was opposed to the teaching of the Bible, which says "Thou shalt not kill."

Esquirol thinks some threatening law against the individual should be enforced with reference to the social usages of the people of each particular country. He says comminatory laws have caused suicide to cease in Egypt and Miletus.

Legislation, though not powerful to accomplish much, should nevertheless exist. It will undoubtedly deter a few, and this alone will prove its usefulness.

The attempt at suicide is punishable in New York State by five years imprisonment, according to existing laws recently enacted.

The confiscation of property and denial of the right of burial, formerly practised in France, have, of late years, been stricken from the Code.

Formerly, in England, the body of a suicide was treated with ignominy, buried in the highway, and transfixed by a stake. When this law was abolished, the body could still only be buried at night and without religious rites. The Canons of the Roman Catholic Church still forbid the burial of a suicide in consecrated ground.

The laws of antiquity, severe as they were upon the family, name, and possessions of the individual, had but slight effect in repressing suicide, as they naturally would have in the insane, who contribute most largely. In some countries the bodies of all suicides are given for dissection.

The public press has it in its power to favor an increase in suicide by publishing, with minute details, descriptions of all suicides, thus exciting depraved tastes, pampering to the vicious, and putting ideas regarding the act into the minds of nervously weak and predisposed persons. Fortunately, this tendency is much less marked than at a former period, but the danger should be constantly pointed out and guarded against when suicides become at all frequent in a community.

Silence is the antidote for this form of nervous, imitative suicide, as Moreau has aptly and truly said.

TREATMENT.—When a tendency to self-destruction has been discovered, moral treatment may be of much benefit. Kindness, cheerful attention, and society, and the assurance of aid and support may brighten hope. Argument and sympathy have never done good. When an individual threatens to kill himself, the best treatment is probably to tell him to go ahead and do it. This usually results in a cessation of the threats.

Those mentally afflicted should be placed in institutions, and it has been recommended that all having suicidal tendency be placed together, at least at night, and this plan is carried out in many of our institutions.

Tonics and sedatives are usually called for, and remedies suited to the physical derangement, whatever that may be.

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SULPHIDES. Sulphides of four metallic bases occur among medicines, namely, sulphides of *mercury*, *antimony*, *potassium*, and *calcium*. Of these, the sulphides of mercury and antimony are medicinally not specifically peculiar, and will be found discussed under the titles of the several metals. The sulphides of the other two bases exhibit marked properties, evidently due to the sulphur of their composition, and form thus a distinct group of medicines. The common characteristics are the possession of, physically, an alkaline reaction, a disagreeable smell, and an alkaline and offensive sulphuretted taste; physiologically, quite intense, irritant properties, and a special obnoxiousness to animal and vegetable skin parasites; and, therapeutically, a local healing influence over many skin diseases in their chronic stage, and, given internally, an uncertain tendency to abate chronic glandular, or cutaneous, or arthritic disease, and to control or repress suppuration. In full dose too long continued, the compounds tend to impair general nutrition, leading to emaciation and muscular weakness. Following are in detail the pharmaceutical preparations containing the sulphides in question, with their special properties and uses:

Potassa Sulphurata: *Sulphurated Potassa.*—This is an officinal preparation of the United States Pharmacopœia, made by heating in a covered crucible to melting a mixture of dried potassic carbonate and sublimed sulphur. The product solidifies upon cooling, and is then broken into pieces and put up in well-stopped bottles of hard glass. Products obtained by the foregoing general process are commonly called, generically, *hepar sulphuris* (liver of sulphur), the name being expressive of the color. Such products are composite bodies, but the composition varies according to the degree of heat to which the mixture of potassic carbonate and sulphur has been subjected in the preparation. By the comparatively low heat directed in the United States pharmacopœial process, the product is probably a mixture of potassic hyposulphite and trisulphide ($K_2S_2O_3 + 2K_2S_3$). At a higher heat, such as is used in the British pharmacopœial process, the hyposulphite first formed splits into potassic sulphate and pentasulphide. Sulphurated potassa appears in "irregular pieces of a liver-brown color when freshly prepared, turning gradually to greenish-yellow or brownish-yellow, having a faint, disagreeable odor, a bitter, alkaline, repulsive taste, and an alkaline reaction. Soluble in about two parts of water at 15° C. (59° F.), with the exception of a small residue; partly soluble in alcohol, the latter leaving undissolved the accompanying impurities. The aqueous solution has an orange-yellow color, and exhales the odor of hydrosulphuric acid. The latter is abundantly evolved on the addition of hydrochloric acid, while, at the same time, sulphur is deposited" (U. S. Ph.). The product should contain at least fifty-six per cent. of the potassic sulphide. It is decomposed by mineral acids, and by most solutions of metallic salts.

Sulphurated potassa possesses the general properties detailed above; it is violently irritant, even to corrosiveness, and overdosage may easily kill by excessive gastro-intestinal irritation. The medicine is used, locally, to kill parasites, and to favor the healing of skin disease or the abatement of rheumatic or gouty troubles, and, internally, to assist in the two latter-named operations. The parasiticide action is utilized mainly for the destruction of the itch-insect, for which purpose this compound is exceedingly efficacious. The preparation is applied locally, in the form of ointment, lotion, or general bath. For an ointment of proper average strength, sulphurated potassa may be mixed with lard in the proportion of six per cent. of the former; for a lotion, an aqueous solution ranging from three to six per cent. in strength may be used; and, for a bath, about 125.00 Gm. (four ounces) may be dissolved in about 120 litres of water (about thirty gallons). Concentrated applications should never be made, because of the sharp irritation which would thereby certainly be set up. Baths containing sulphurated potassa (commonly spoken of as *sulphur-baths*), besides their foregoing use, are sometimes employed in the treatment of chronic lead-poisoning, because of the finding that patients suffering from lead-contamination show upon their skins, after immersion in a sulphur-bath, a dark discoloration, as from the forming there of lead sulphide. The inference is that the sulphur in some mysterious way coaxes the lead out of the system through the skin-emunctories, in order to satisfy its chemical longing for a union with the metal. Sulphur-baths are administered warm or hot, and of a duration from half an hour to two or three hours. They are apt, particularly when protracted, to produce a good deal of irritation of the skin, even to the development of a papular or vesicular eruption. These baths should be prepared in wooden tubs. For internal giving, the dose of sulphurated potassa ranges from 0.12 to 0.40 Gm. (two to six grains), several times a day, given in pill, or in some aromatized syrup.

Calx Sulphurata: *Sulphurated Lime.*—The preparation thus named in the United States Pharmacopœia is what is commonly, but incorrectly, called *sulphide of calcium*. It is a mixture in varying proportions of calcic sulphide and calcic sulphate, but should contain at least thirty-six per cent. of absolute calcic sulphide—the salt which gives the substance its medicinal activity. Sulphurated lime is made, by the process directed in the United States Pharmacopœia, by heating to a low red heat in a closed crucible a mixture of lime ("quick-lime") and sulphur. The product, after cooling, is pulverized, and at once put up in small glass-stoppered phials. It appears as "a grayish-white or yellowish-white powder, gradually altered by exposure to air, exhaling a faint odor of hydrosulphuric acid, having an

offensive, alkaline taste, and an alkaline reaction. Very slightly soluble in water, and insoluble in alcohol" (U. S. Ph.).

Sulphurated lime, like sulphurated potassa, has the general properties of the alkaline sulphides, as already detailed. It is powerfully irritant, even medicinal doses being apt to upset the stomach. And it is a disagreeable medicine for internal taking, also, because of its giving rise to eructations of sulphuretted gases. The preparation has been used, locally, principally as a depilatory, the powder being applied directly to the hairy area, and after fifteen minutes the part gone over with a wet sponge. Medicine and hairs then come away together. Internally, sulphurated lime has rather recently acquired a reputation as tending to control suppurations, the discharge lessening in quantity, and their unhealthy pus acquiring a healthier character under the influence of the medicine. Given between times in recurring suppurations, as in recurring crops of boils, it is also held to abate the frequency and severity of the attacks. The dose of sulphurated lime ranges from 0.003 to 0.006 Gm. (one-twentieth to one-tenth of a grain), several times a day, or even hourly, given most conveniently in trituration with sugar of milk. *Edward Curtis.*

SULPHITES AND "HYPOSULPHITES" (Thiosulphates). I. General Medicinal Properties of Sulphites and "Hyposulphites."—A number of sulphites and "hyposulphites" being used in medicine because of a virtue which they are considered to derive, in common, from their acid radicles, such salts form a distinct group of medicines, which it is convenient to discuss under a single heading. The class-characteristics are as follows: The salts are soluble in water, have a combined saline and sulphurous flavor, and are, in physiological operation, locally bland and constitutionally innocuous. From a medicinal point of view, their most important reaction is that in the presence of stronger acids they are decomposed, with the evolution of sulphurous acid. Given medicinally, they are thought to undergo this change in the stomach through the agency of the free acid of the gastric juice. The decomposition is said to be slower with "hyposulphites" than with sulphites. As a secondary result of the chemical change, sulphates are formed, such being the combination in which the base reappears in the urine when a sulphite or "hyposulphite" is swallowed in ordinary dosage. Medicinally, these salts are employed with the single view of obtaining by their means the germicide and antiseptic action of sulphurous acid. But in this connection it must be carefully borne in mind that sulphites and "hyposulphites," while maintaining their chemical composition as such, have been experimentally proved to be practically devoid of either germicide or antiseptic power.[1] They can, therefore, even theoretically, be of avail in this line only under circumstances determining their decomposition and the evolution thereby of sulphurous acid. Such reaction may take place in the stomach, but is seemingly impossible in the blood, and with the inference naturally following from these premises clinical experience is in accord. For these salts have been vaunted in the treatment of pyrosis and sarcinæ, and their employment has proved fairly efficacious; but they have been even more strenuously advocated for the treatment of constitutional diseases assumed to be caused by infection of living organisms (Nolli), and have, in the hands of the majority of the profession at least, signally failed. The salts have also been used, with variously reported success, as lotions for the cure of parasitic skin disease, or for the abatement of the pain of chilblains, sprains, etc.—applications in which it is certainly doubtful if they exert any specific influence.

II. The medicinally used Sulphites and "Hyposulphites."—The salts of this category are the normal sulphite of *potassium*, the normal and acid sulphite, respectively, of *sodium*, the sulphite of *magnesium*, and the normal thiosulphate of *sodium* (commonly called *hyposulphite*).

Normal Potassic Sulphite, $K_2SO_3.2H_2O$.—The salt is officinal in the United States Pharmacopœia under the title *Potassii Sulphis*, Sulphite of Potassium. It occurs as "white, opaque, obliquely rhombic, octahedral crystals, or a crystalline powder, somewhat deliquescent, odorless, having a bitter, saline, and sulphurous taste, and a neutral or feebly alkaline reaction. Soluble in four parts of water at 15° C. (59° F.), and in five parts of boiling water; only sparingly soluble in alcohol. When gently heated, the salt loses its water of crystallization (18.5 per cent.); at a red heat it is decomposed and leaves a residue of an alkaline reaction" (U. S. Ph.). The salt should be kept in well-stopped bottles.

Potassic sulphite may be used locally in twelve per cent. aqueous solution, or given internally in doses ranging from 1.00 to 4.00 Gm. (fifteen to sixty grains), three or four times a day.

Normal Sodic Sulphite, $Na_2SO_3.7H_2O$.—The salt is officinal in the United States Pharmacopœia as *Sodii Sulphis*, Sulphite of Sodium. It occurs in "colorless, transparent, monoclinic prisms, efflorescent in dry air, odorless, having a cooling, saline, and sulphurous taste, and a neutral or feebly alkaline reaction. Soluble in four parts of water at 15° C. (59° F.), and in 0.9 part of boiling water; only sparingly soluble in alcohol. When gently heated, the salt melts, then loses its water (fifty per cent.), and at a red heat it is decomposed and leaves a residue having an alkaline reaction. A fragment of the salt imparts to a non-luminous flame an intense yellow color, not appearing more than transiently red when observed through a blue glass" (U. S. Ph.). The salt should be kept in well-stopped bottles, in a cool place.

Sodic sulphite may be used in same manner and dose as the potassic salt.

Acid Sodic Sulphite, $NaHSO_3$.—The salt is officinal in the United States Pharmacopœia as *Sodii Bisulphis*, Bisulphite of Sodium. It occurs in "opaque, prismatic crystals, or a crystalline or granular powder, slowly oxidized, and losing sulphurous acid on exposure to air, having a faint, sulphurous odor, a disagreeable, sulphurous taste, and an acid reaction. Soluble in four parts of water, and in seventy-two parts of alcohol at 15° C. (59° F.); in two parts of boiling water, and in forty-nine parts of boiling alcohol. When strongly heated, the salt decrepitates, and is converted into sulphur and sulphate of sodium. A small fragment of the salt imparts to a non-luminous flame an intense yellow color, not appearing more than transiently red when observed through a blue glass" (U. S. Ph.). This salt must be kept in well-stopped bottles.

This sulphite is less stable than the normal sodic salt, and more disagreeable to taste. In other respects it is similar.

Magnesic Sulphite, $MgSO_3.6H_2O$.—The salt is officinal in the United States Pharmacopœia as *Magnesii Sulphis*, Sulphite of Magnesium. It occurs as a "white, crystalline powder, gradually becoming oxidized on exposure to air, odorless, having a slightly bitter, somewhat sulphurous taste, and a neutral or slightly alkaline reaction. Soluble in twenty parts of water at 15° C. (59° F.), and in nineteen parts of boiling water; insoluble in alcohol. When heated to 200° C. (392° F.), the salt loses its water of crystallization (50.9 per cent.), and is converted into magnesia and anhydrous sulphate of magnesium" (U. S. Ph.). The salt should be kept in well-stopped bottles.

Magnesic sulphite is the least unpleasant of the sulphites to taste. Uses and dose as with the potassic salt.

Normal Sodic Thiosulphate ("Hyposulphite"), $Na_2S_2O_3.5H_2O$.—The salt is officinal in the United States Pharmacopœia under its former chemical title of *Sodii Hyposulphis*, Hyposulphite of Sodium. The present confusion in the use of the term *hyposulphite* arises from the fact that before the discovery by Schützenberger of what is now, and properly, called hyposulphurous acid—namely, the body H_2SO_2—the name in question was applied to thiosulphuric acid ($H_2S_2O_3$). Hence it comes about that though a true sodic hyposulphite is known, the salt that passes current by that name is not a hyposulphite, but a thiosulphate. The old title, however, is so firmly fixed by long and popular usage that it has been retained by

the United States Pharmacopœia, and is the title by which the salt is universally known as a medicine. Sodic "hypo-sulphite" occurs as "large, colorless, transparent, monoclinic prisms or plates, efflorescent in dry air, odorless, having a cooling, somewhat bitter and sulphurous taste, and a neutral or faintly alkaline reaction. Soluble in 1.5 part of water at 15° C. (59° F.), and in 0.5 part of boiling water, in the latter case with partial decomposition; insoluble in alcohol. When rapidly heated to about 50° C. (122° F.), the salt melts; when slowly heated until it is effloresced, and afterward to 100° C. (212° F.), it loses all its water (36.3 per cent.), and at a low red heat it is decomposed. A fragment of the salt imparts to a non-luminous flame an intense yellow color, not appearing more than transiently red when observed through a blue glass" (U. S. Ph.). The salt must be kept in well-stopped bottles.

Sodic "hyposulphite" is more stable than the sulphites, undergoing decomposition by acids less easily. In properties, uses, and modes of administration it resembles potassic sulphite. The internal dose is generally from 1.00 to 1.30 Gm. (fifteen to twenty grains).

Edward Curtis.

[1] Sternberg: American Journal of the Medical Sciences, April, 1883, p. 321.

SULPHOCARBOLATES: *Phenolsulphonates.* Carbolic acid (*phenol*), added to strong sulphuric acid, dissolves with the formation of the acid body, $C_6H_4(OH).SO_3H$, termed *phenolsulphonic acid* by the chemist, but commonly known as *sulphocarbolic acid.* Sulphocarbolic acid unites with bases to the formation of salts, and in these salts it was hoped there might be found substances which would retain the therapeutic powers of carbolic acid while free from the poisonous properties of that body. So far as observation has gone, however, this hope does not seem to have been realized. A single salt of sulphocarbolic acid is officinal in the United States Pharmacopœia, as follows:

SODII SULPHOCARBOLAS, *Sulphocarbolate of Sodium,* $NaC_6H_5SO_4.2H_2O$, U. S. Ph.—This salt is described as "colorless, transparent, rhombic prisms, permanent in the air, odorless or nearly so, having a cooling, saline, somewhat bitter taste, and a neutral reaction. Soluble in 5 parts of water, and in 132 parts of alcohol at 15° C. (59° F.); in 0.7 part of boiling water, and in 10 parts of boiling alcohol. When heated, the salt loses its water and becomes a white powder" (U. S. Ph.). This is a bland salt, producing but little constitutional disturbance in ordinary medicinal doses beyond some lightness of the head. It has been prescribed in doses ranging from 0.65 to 2.00 Gm. (from ten to thirty grains) for the purpose of constitutional antisepsis in so-called zymotic diseases, but without striking results. *Edward Curtis.*

SULPHO-SALINE SPRINGS. *Location and Post Office,* Cincinnati, Hamilton County, O.

ANALYSIS (E. S. Wayne).—One pint contains:

	Grains.
Carbonate of magnesia	1.141
Carbonate of lime	2.417
Chloride of potassium	0.493
Chloride of sodium	66.846
Chloride of magnesium	2.157
Chloride of calcium	2.773
Chloride of lithium	0.029
Sulphate of potassa	0.287
Sulphate of lime	3.650
Phosphate of soda	0.167
Iodide of magnesium	0.037
Bromide of magnesium	0.049
Oxide of iron	0.053
Silica	0.098
Total	80.197
Gas.	Cub. in.
Carbonic acid	1.57
Sulphuretted hydrogen	0.91

THERAPEUTIC PROPERTIES.—This well is a strong sulpho-saline one, and has a local reputation as a cathartic and alterative. As warm baths, the water is very useful in chronic skin diseases, and rheumatism.

This water flows from an artesian well (2,408 feet deep), bored for the purpose of supplying a brewery. Being unfit, on account of its mineral properties, for that purpose, it has been utilized as a mineral spring, and a large bath-house has been erected, furnished with every convenience. The water has a temperature of 62° F. and is abundant. *G. B. F.*

SULPHUR. Sulphur is used in medicine in the condition of fine powder, three styles of which are officinal in the U. S. Pharmacopœia, as follows:

SULPHUR SUBLIMATUM, *Sublimed Sulphur.*—This preparation, commonly called *flowers of sulphur,* is crude sulphur purified by distillation in an apparatus so arranged that the vaporized sulphur shall condense in the form of a powder upon the walls of the receiving chamber. Sublimed sulphur is a "fine, citron-yellow powder, of a slight, characteristic odor, and generally of a faintly acid taste, and an acid reaction. It is insoluble in water or alcohol. When ignited, it burns with a blue flame, forming sulphurous acid gas, and leaving no residue, or only a trace" (U. S. Ph.). Sublimed sulphur always contains a little sulphuric acid, whereby it is unfitted for internal medicinal use.

Sulphur Lotum, Washed Sulphur.—This preparation is simply sublimed sulphur freed from contaminating sulphuric acid. The sulphur is digested for three days with diluted water of ammonia, by which process the sulphuric acid is fixed as ammonic sulphate, and the mass is then thoroughly washed with water upon a muslin strainer. The ammonic sulphate is thus washed away, and the purified sulphur is finally dried at a gentle heat, and passed through a No. 30 sieve. Washed sulphur is "a fine, citron-yellow powder, odorless and almost tasteless, insoluble in water or alcohol, but completely soluble in a boiling solution of soda, or in disulphide of carbon. When heated to 115° C. (239° F.), washed sulphur melts, and at a higher temperature it is volatilized, without leaving more than a trace of residue. Water agitated with it should not redden blue litmus paper (abs. of free acid.)" (U. S. Ph.). When derived from a sulphur originally obtained from metallic sulphides, washed sulphur may contain the very dangerously contaminating substance, arsenic, in the form of the trioxide or trisulphide of that element. Proof of absence of arsenic is afforded by digesting a sample of washed sulphur with two parts of ammonia, filtering, and finding the filtrate unaffected by super-saturation with hydrochloric acid, and not precipitated by passing through it a stream of hydrogen sulphide.

SULPHUR PRECIPITATUM, *Precipitated Sulphur.*—This preparation, formerly known as *milk of sulphur,* is an exceedingly fine powder of sulphur, gotten by precipitating with diluted hydrochloric acid a solution of sulphur salts of calcium, obtained by mixing sublimed sulphur and slaked lime with water. The sulphur, after precipitation, is collected upon a strainer, thoroughly washed with water, and dried at a gentle heat. Precipitated sulphur is "a very fine, yellowish-white, amorphous powder, odorless and almost tasteless, insoluble in water or in alcohol, but completely soluble in a boiling solution of soda or in disulphide of carbon. By heat it is completely volatilized" (U. S. Ph.). Precipitated sulphur should stand the same tests for absence of free acid and of contaminating arsenic as washed sulphur (see above). This variety of sulphur-powder differs from the foregoing in being lighter in color, and of finer particles. From the latter fact it derives the advantages of greater smoothness and readiness of mixing with fluids; but, to offset, it has the disadvantage of tending to develop an acid upon keeping.

Sulphur, as the pharmacopœial descriptions say, is insoluble in water, and practically so in alcohol, but dissolves in varying proportions in solutions of the alkalies and in oils, fixed and volatile. Because of its insolubility in aqueous fluids, sulphur is practically devoid of physiological activity while under its own form, but, when rubbed in ointment upon the skin, or when taken internally, a feebly irritant action appears, presumably

due to a sulphide formed in small quantity by the chemicals present in the secretions of the part. What little of an internally taken dose of sulphur is absorbed is also probably in the condition of a sulphide, and the constitutional effects that follow are a feeble reflex of those of the alkaline sulphides (see Sulphides). In single, considerable dose the local irritation displayed by sulphur determines increased intestinal activity, showing itself by relaxation of the bowels, but this with but little increase of secretion. The stools are therefore generally composed of solid or semi-solid fecal matter, and the operation of the medicine is mild and slow, the call to stool rarely occurring until from six to eight hours after the taking of the sulphur. If habitually used as a laxative, sulphur may induce a low catarrh of the alimentary tract. A disagreeable feature of its internal taking for any purpose is the tendency to the generation of flatus, offensive from the presence of sulphuretted gases.

The therapeutic applications of sulphur are as follows: By some it is given internally as a means of getting the constitutional effects of the sulphides in constitutional diseases, but by the majority of practitioners the internal use is in laxative dose only, for a laxative effect. Such dose is from 4.00 to 12.00 Gm. (one to three drachms), the washed or precipitated preparations being selected, and the powder mixed with molasses or diffused in milk for the taking. Externally, ointments containing sulphur are a good deal used as mildly irritant applications in skin diseases generally, and, specifically, as efficient parasiticidal dressings in itch. The pharmaceutical preparations of the United States Pharmacopœia are as follows:

Unguentum Sulphuris, Sulphur Ointment.—This preparation is compounded of thirty parts of sublimed sulphur and seventy of benzoinated lard, thoroughly incorporated. It may be applied without dilution, and is a very commonly used ointment for the treatment of the itch. It has a disagreeable sulphuretted smell, which may be to a certain degree masked by the addition of a little of some odoriferous volatile oil.

Unguentum Sulphuris Alkalinum, Alkaline Sulphur Ointment.—Washed sulphur and half the quantity of potassic carbonate are rubbed together with a little water, and the whole then thoroughly mixed with benzoinated lard. The finished ointment contains twenty per cent. of sulphur. In this preparation the alkali of the potassic compound probably determines a more rapid solution of the sulphur, so that the ointment is more prompt and thorough in action than the simple one just described, but it is for that reason more likely to provoke untoward irritation. *Edward Curtis.*

SULPHUR DIOXIDE (formula SO_2). This compound, commonly miscalled *sulphurous acid gas*, is the product of the combustion of sulphur in air. It is a colorless gas, of a well-known characteristic "sulphurous" odor, and is both offensive to the nostrils and intensely irritant to the larynx. Even the fumes of a single burning sulphur match-head easily excite coughing, and air highly charged with the gas is fatal to life. Sulphur dioxide dissolves freely in water—in one-fiftieth of its volume at ordinary temperatures—forming in the process of solution an acid body, *sulphurous acid* proper (H_2SO_3) (see Sulphurous Acid).

The medicinally valuable property of sulphur dioxide is its peculiar noxiousness to the vitality of disease-germs—a germicidal potency in which this compound, among gases, is rivalled only by chlorine and the vapors, respectively, of bromine and of iodine. And considering the cheapness and ease with which, by the simple combustion of sulphur, sulphur dioxide can be obtained, the gas leads the list of practically available and really efficient aërial disinfectants. Yet in its application the inherent uncertainties in the general method of aërial disinfection must never be forgotten. Could we be certain that every disease-germ present in a chamber would be fully exposed to the action of the disinfectant gas, then we might rely with corresponding fulness upon the disinfection thus attained; but when we bethink us how easily these germs, microscopic in size, may be safely fortified against assaults of a gas by lodgement in cracks and crannies of furniture and fabrics, then we cannot but realize the important truth, that even the most thorough so-called disinfection by this, the most potent of the practically available aërial disinfectants, is at best but an unreliable procedure. In this connection the strong and offensive smell of sulphur dioxide is a distinct advantage, since, after fumigation by the gas, a chamber and all articles therein must be thoroughly aired, and thus additionally disinfected, before the human nose will permit of their resumed use.

For the determination of the exact germicidal power of sulphur dioxide, very careful experiments were made by Sternberg,[1] by submitting vaccine virus, moistened with glycerin on the one hand, and dried upon ivory-points upon the other, to the action, in a closed chamber, of air charged with varying percentages of sulphur dioxide, the exposure ranging from six to twelve hours. After exposure the virus, or the charged ivory-points, were used for vaccination side by side with some of the same sample of virus which had not been exposed to the germicide. The general results were that, in the case of moist lymph, destruction of infective power followed a twelve-hour exposure to air charged with a proportion of sulphur dioxide such as would be produced by burning three-quarters of a grain of sulphur for each cubic foot of air; and, in the case of the dried virus, similar results followed with an impregnation equivalent to the combustion, per cubic foot of air, of three grains of sulphur. These results accord with common experience, and teach that at least a one per cent. impregnation of air with sulphur dioxide will ordinarily be required to sterilize floating germs.

For the practical application of sulphur dioxide as an aërial disinfectant, the gas is most easily and cheaply obtained by burning sulphur, and in calculating the quantity of sulphur required it is obviously wisest to err very far on the safe side. A good rule is therefore to allow from two to three pounds for each one thousand cubic feet of chamber to be disinfected. The strength of fumes thus generated being vastly in excess of what is respirable, the procedure is only possible in vacated rooms. In a chamber to be operated upon, therefore, all living creatures must be removed, and every possible outlet for the gas, such as door-ways, windows, and chimneys, must be closed, and even cracks and key-holes should be stopped with cotton or pasted over with paper. Then all articles needing disinfection must be thoroughly exposed on all sides to free access of the gas—bureau-drawers being opened, carpets, curtains, and blankets hung over lines across the room, and mattresses ripped open and the hair loosely strewn on the floor. The proper quantity of sulphur, in the form of sublimed sulphur, is then best mixed with one-fortieth of its weight of powdered charcoal, to secure readier combustion, and put into an iron pot, or upon a metal plate resting upon the legs of a half-open pair of tongs set across a wash-tub half full of water. By these precautions all danger of accidental setting of the floor on fire is avoided. A single door being left unsealed, the operator fires the sulphur by a live coal or a teaspoonful of flaming alcohol, and immediately retires, closing and sealing the door behind him. The sulphur is left to burn itself out, and next day the chamber is cautiously entered, the windows thrown open, and all articles thoroughly aired. It is possible also to generate sulphur dioxide by burning carbon disulphide in a specially constructed lamp, but from the great inflammability of that compound the procedure is not altogether safe, and presents no advantages over the simple method by the combustion of sulphur.

Edward Curtis.

[1] American Journal of the Medical Sciences, April, 1883.

SULPHUR IODIDE. Under the title *Sulphuris Iodidum*, Iodide of Sulphur, the United States Pharmacopœia recognizes a preparation made by fusing by heat a mixture of one part of washed sulphur and four parts of iodine. The fused mass, after cooling, is broken into pieces and

kept in glass-stoppered bottles. The article is described as "a grayish-black solid, generally in pieces, having a radiated, crystalline appearance, the characteristic odor of iodine, a somewhat acrid taste, and a faintly acid reaction. It is insoluble in water, but very soluble in disulphide of carbon; also soluble in about sixty parts of glycerin. Alcohol and ether dissolve out all the iodine, leaving the sulphur. When exposed to the air it gradually loses iodine. On being heated, it sublimes, the first part of the sublimate consisting of iodine, and the subsequent portion containing both iodine and sulphur. On continued heating it is volatilized, without leaving more than a trace of residue. If 100 parts of Iodide of Sulphur be thoroughly boiled with water, all the iodine will escape, and about 20 parts of sulphur will remain" (U. S. Ph.).

This substance is differently regarded by chemists, some considering it a definite compound, corresponding to the formula I_2S_2, and others thinking it more probably a mere physical mixture. If a true chemical compound, it is one of exceptional instability, as the foregoing narration of its properties makes evident. To the therapeutist it presents itself practically as a joint representative of free sulphur and free iodine. It has occasionally been given internally for the purposes for which iodine is so administered, but the commoner employment is external as a gently irritant, iodized application in various skin diseases. It is best applied in the form of ointment made with lard, containing the sulphur iodide in the proportion of about eight per cent.

Edward Curtis.

SULPHURIC ACID: Oil of Vitriol, H_2SO_4. This well-known acid is officinal in the United States Pharmacopœia under the title *Acidum Sulphuricum*, Sulphuric Acid, and is defined to be "a liquid, composed of not less than ninety-six per cent. of absolute sulphuric acid, and not more than four per cent. of water" (U. S. Ph.). Sulphuric acid is a heavy liquid of an oily appearance, colorless when newly made, but apt to acquire a smoky hue upon keeping. The specific gravity varies in different samples, but a gravity of 1.840 is recognized as standard by the U. S. Pharmacopœia. The acid has an intense affinity for water. Mixed with that fluid, it unites therewith with the evolution of considerable heat and with a contraction of volume, forming a clear solution. By reason of the same affinity, many organic bodies are decomposed upon treatment with sulphuric acid, the acid abstracting from their molecule the elements of water. Thus, by dehydration, oxalic acid is chemically broken up, alcohol is converted into ethylene gas (C_2H_4), wood and sugar are blackened, and textile fabrics and animal tissues are destroyed. Sulphuric acid, if diluted, also attacks most of the common metals, the prominent exceptions being gold, platinum, and iridium. Certain of the metals, such as copper, mercury, antimony, bismuth, tin, lead, and silver are also acted upon by the concentrated acid, if the same be heated.

Upon the living animal system strong sulphuric acid acts purely as a powerful caustic. Its action is a spreading one, and the sloughs have a dusky or blackish hue, quite different in color from the yellow sloughs produced by nitric or hydrochloric acids. Swallowed in any quantity, the strong acid is an intense corrosive poison. Burning pain in the mouth, throat, and stomach is experienced in the very act of swallowing, speedily followed by violent vomiting, the ejecta being intensely acid and containing blood. The voice is apt to become changed and whispering, and the shock from the corrosion is usually very severe, the sufferer very likely dying in collapse in from eighteen to twenty-four hours after taking the poison; or, in exceptional cases, even much earlier—in a few instances so early as two or three hours. If the poison be not speedily fatal, parotitis with salivation and nephritis are not uncommon sequelæ. The severity of the poisoning is largely influenced by the fact of presence or absence of food in the stomach, the former condition saving from direct contact of the concentrated acid upon the gastric walls. One drachm is about the least quantity reported to have produced death, and on the other hand, so large quantities as from two to three ounces have been swallowed and the patient has recovered. The lesions in sulphuric acid-poisoning are patches of corrosion where the acid has struck. Mouth, throat, and œsophagus may show whitish, or ashen, or brownish areas of corrosion, and in the stomach patches of brown, or black may alternate with lines of red, where the mucous membrane, protected by foldings from concentrated action of the acid, has escaped corrosion, but has taken on inflammation. Perforation of the stomach is common. The gastric contents are generally discolored a dark brown and are of viscid consistence, and may show no traces of the acid, especially if death have been postponed several days and the patient have been under treatment. In such cases all the acid will have been discharged in the early vomiting. The treatment of sulphuric acid poisoning is to neutralize the acid, and then treat the lesions on general medical principles. For neutralization, magnesia and chalk are commonly chosen; but, as Taylor points out, a soluble alkali like the sodic carbonates, given in solution, will obviously act more certainly and speedily. Whatever alkali be selected, it should be given freely, but, at best, neutralization accomplishes little, since the damage is done at the moment of swallowing the acid. Demulcents, such as milk, gruel, white of egg, and oil should, next, be freely administered. The stomach-pump should be avoided, lest the nozzle perforate the corroded gastric walls; and the spontaneous vomiting is so free that there is no indication for the giving of emetics.

The most important points of medical jurisprudence connected with the subject of sulphuric acid-poisoning are these: First, that fatal poisoning by this agent almost certainly means either suicide or accident. For the acid is so intensely sour that it is hardly conceivable that a fatal dose, criminally offered, would be unsuspectingly quaffed by the intended victim, even though attempted to be disguised in some article of food or drink. Forcible administration to children, or drunken or sleeping persons, is, however, possible, and a few cases of homicide of children by this method have been reported. Next, the jurist must remember that the acid may kill without actual swallowing, death ensuing by asphyxia from swelling of the larynx, corroded by the poison; and, next, that in any case the mouth and lips may show no marks of the acid if the draught have been taken from a *spoon*. In rare cases even throat and œsophagus have shown no signs of corrosion. Again, although the symptoms almost invariably begin immediately upon swallowing, even if the potion have been one of diluted acid, and the pain is intensest agony, yet the sufferer may at first be able to walk and even disguise his sufferings from the notice of casual observers. As regards period of death, the acid has killed in so short a time as one hour, and at all intermediate periods thereafter up to the lapse of two years. Rapid deaths are generally by suffocation, from occlusion of the larynx, and long delayed ones from stricture of the œsophagus.

Therapeutically, strong sulphuric acid is occasionally used as a caustic, but the very intensity of its action is in its disfavor, so that nitric acid is generally preferred. The acid must be kept in glass-stoppered bottles.

Diluted, so as not to be corrosive, sulphuric acid, like all sour acids, tends to check acid, and to increase alkaline secretions, to inhibit fermentations, and, of course, to neutralize alkalinity. Dilute preparations of sulphuric acid are, therefore, available to repress morbid sweatings, both applied locally as lotions, and given internally to allay thirst and quicken appetite; to prevent fermentation of food in the primæ viæ, and so to cure diarrhœas due to the irritation of the products of such fermentations, and to neutralize the alkali of alkaline pyrosis. For these various purposes the following officinal preparations of the United States Pharmacopœia are available:

Acidum Sulphuricum Dilutum, *Diluted Sulphuric Acid.*—This preparation is a simple aqueous dilution of sulphuric acid, of ten per cent. strength. It is a colorless

fluid, intensely sour of taste, and of about the specific gravity 1.067. It should be kept in glass-stoppered bottles. This grade of acid, although not corrosive, is quite irritant, and, for medical use, requires considerable further dilution. The dose is from ten to thirty drops, diluted thirty- or forty-fold, and to be taken through a tube, with the mouth well rinsed after the swallowing.

Acidum Sulphuricum Aromaticum, *Aromatic Sulphuric Acid, Elixir of Vitriol.*—This preparation consists of alcohol charged with sulphuric acid and tincture of ginger, and flavored, in addition, with a trace of oil of cinnamon. In 1,000 parts of product are represented 200 parts of sulphuric acid, 45 of tincture of ginger, and 1 of oil of cinnamon. The preparation is a limpid, yellow fluid of an aromatic, ethereal, and strongly sour taste, and of the specific gravity 0.955. As its odor suggests, it probably contains some ethereal product of a reaction between the acid and alcohol of its composition. The United States Pharmacopœia considers, thus, that there is a certain amount of ethyl-sulphuric acid present. Aromatic sulphuric acid should be kept in glass-stoppered bottles.

This preparation is the favorite one for the internal administration of sulphuric acid. It is to be given in the same manner as the dilute acid (see above), and in the same or somewhat lesser doses.

Edward Curtis.

SULPHUROUS ACID, H_2SO_3. Sulphur dioxide gas (SO_2) is readily absorbed by water, and in so dissolving is to be regarded as uniting with water, molecule for molecule, with the formation of the acid body, H_2SO_3. The United States Pharmacopœia recognizes under the officinal title *Acidum Sulphurosum*, Sulphurous Acid, an acid representing 3.5 per cent. of sulphur dioxide and 96.5 per cent. of water, and of the specific gravity 1.022 to 1.023. Sulphurous acid is a colorless fluid, smelling pungently of sulphur dioxide, and tasting both sulphurous and sour. It has a strong acid reaction, and first reddens and then bleaches litmus paper. It is wholly volatilized by heat, and tends constantly to undergo conversion into sulphuric acid by the absorption of oxygen. This change is hastened by the action of light, hence the Pharmacopœia directs that sulphurous acid be put up in glass-stoppered, dark amber-colored bottles, and be kept in a cool and dark place. The pharmacopœial process for making the acid is to generate sulphur dioxide by heating a mixture of sulphuric acid and charcoal, and to conduct the mixed sulphur and carbon dioxides into distilled water. The sulphur dioxide dissolves in the water with the formation of sulphurous acid, and the carbon dioxide mostly escapes.

In its medicinal properties sulphurous acid resembles sulphur dioxide (see Sulphur Dioxide), and may be practically regarded, indeed, as a simple aqueous solution of that compound. It is a pretty potent germicide, and upon tender surfaces of the animal body is decidedly irritant. It bleaches vegetable colors. The acid is used, externally, as a wash in parasitic skin diseases, generally diluted two- or three-fold, and, internally, is occasionally prescribed in cases of pyrosis and sarcinæ. It is, however, an exceedingly disagreeable medicine to take. The dose is 4.00 Gm. (about one fluidrachm) of the officinal acid, taken in a wineglassful of water.

Edward Curtis.

SULPHUR SPRINGS (TEXAS). *Location and Post-office,* Sulphur Springs, Hopkins County, Tex.

Access.—By the Jefferson Branch of the Missouri Pacific Railway.

Analysis.—Dr. J. M. Hooper, of Sulphur Springs, Hopkins County, Tex., sends us the following analyses of the water of two wells in that town. There is one well, he remarks, that has not yet been examined, which is thought, however, to be superior to these. He adds that he will be happy to answer any questions about the waters of the various wells in the town.

The water of the Weaver Well is acid in reaction, with a specific gravity of 1.008, and each gallon contains the following solid constituents:

	Grains
Sulphate of ferric oxide	33.421
Sulphate of aluminium	23.235
Sulphate of magnesium	24.345
Sulphate of lime	45.678
Sulphate of sodium	1.342
Sulphate of potassium	0.849
Chloride of sodium	1.560
Carbonate of lime	4.286
Phosphate of lime	0.633
Silicic acid	1.425
Free sulphuric acid	1.211
Nitrous acid	trace
Organic matter	2.473

The Pate Sour Well, also of acid reaction, has a specific gravity of 1.0096, and in each gallon the following solid constituents have been found:

	Grains.
Calcic sulphate	84.713
Ferric sulphate	63.194
Magnesic sulphate	22.991
Sodic chloride	5.017
Silex	1.944
Organic and volatile matter	3.797
Free sulphuric acid	1.321
Iodine	trace

G. B. F.

SUMACH (*Rhus Glabra*, U. S. Ph.). "The fruit of *Rhus glabra* Linn.; Order, *Anacardiaceæ*" (*Terebinthaceæ*). The smooth sumach is a very common, and, when in full fruit, a very striking, American shrub. It has, like all its genus, large pinnate leaves and small, polygamous, greenish, regular, pentamerous flowers in panicles; ovary single, one-ovuled; styles or stigmas three. This species has smooth, somewhat glaucous leaves, white beneath, of from eleven to thirty-one leaflets, and close, upright, terminal, conical panicles of flowers and fruit. Berries, when ripe, of a most brilliant crimson color; they are "sub-globular, about one-eighth of an inch (3 millimetres) in diameter, drupaceous, crimson, densely hairy, containing a roundish-oblong, smooth putamen. It is inodorous, and its taste acidulous." The pleasant acid taste of sumach berries is all in the crimson pubescence with which they are covered, and is due to malic acid and acid malate of lime; the internal parts of the seed contain, like the rest of the plant, tannic acid. A fluid extract (*Extractum Rhois Glabræ Fluidum*, U. S. Ph., strength $\frac{1}{10}$) is officinal. Either this diluted, or a decoction, may be used as a pleasantly sour, astringent gargle.

Allied Plants.—See Ivy, Poison.

Allied Drugs.—Tamarinds, Barberries, Rose Hips, etc.

W. P. Bolles.

SUMBUL, U. S. Ph. (*Sumbul Radix*, Br. Ph., Musk-root). The root of *Ferula Sumbul* Hook., f.; Order, *Umbelliferæ*. This large perennial herb, belonging to the asafœtida-, galbanum-, and ammoniacum-yielding group of the family, has a large, rather short, cylindrical root, attaining a diameter of four or five inches, and a length of say a foot, when it divides into several stout branches, and a tall, erect, rather simple stem, six or eight feet in height. The leaves are large, tripinnate, with broad, sheathing petioles. Flowers small, greenish, polygamous, in compound naked umbels. All parts of the plant, but especially the root, exude a resinous, fragrant, milky juice (Bently and Trimen, 131). The sumbul plant is a recent addition to medical botany, having been discovered by Fedschenko in Central Asia, in 1869. The root itself as a perfume, and afterward as a medicine, appeared in Europe about 1840.

Sumbul root comes in transverse slices, one or two or more inches in diameter, and from one-half to an inch in thickness; the surface of these dried disks is a dirty brown, or gray marbled with dirty white; the edges have a dark, loose, papery bark. Resin drops can be seen on it by aid of a lens. The tissue is hard, but spongy; odor decidedly like that of musk, but weaker.

Composition.—The most important constituent is the *resin*, of which there is nine per cent. (Flückiger); it has

a musky smell, more developed in contact with water, and a bitter, aromatic taste. The root contains also a small quantity of dull-bluish colored oil.

Action and Use.—Sumbul has not any important medicinal value; like asafœtida, and its namesake, musk, it is gently stimulant and slightly anti-spasmodic, and may be given for the same nervous conditions as they; but its principal employment is in the preparation of some perfumes, where it takes the place of musk. A tincture (*Tinctura Sumbul*, strength $\frac{1}{10}$) is officinal.

Allied Plants.—See Anise.

Allied Drugs.—Asafœtida, Musk, Valerian.

W. P. Bolles.

SUMMIT MINERAL SPRING. *Location and Post-office*, Harrison, Cumberland County, Me.

Access.—By the Grand Trunk Railway to Norway Station; thence by conveyance nine miles to the spring.

Analysis (46° F., F. L. Bartlett).—One pint contains:

	Grains.
Carbonate of soda and potassa	0.175
Carbonate of magnesia	0.031
Carbonate of lime	0.123
Chloride of sodium	0.021
Oxide of iron and alumina	traces
Silica	0.122
Organic and volatile matter	0.029
Total	0.501

Therapeutic Properties.—This is almost an absolutely pure water, and on that account alone it should be valuable as a solvent and general tonic. The State of Maine abounds in these pure springs, some of which have established reputations as therapeutic agents—for example, the Poland and the Underwood Spring.

G. B. F.

SUMMIT SODA SPRINGS. *Location*, Alpine County, Cal.

Access.—By Central Pacific Railroad to Soda Springs Station; thence by stage twelve miles to the springs.

Analysis.—One gallon contains:

	Grains.
Bicarbonate of lime	43.20
Carbonate of magnesia	4.20
Carbonate of soda	9.50
Chloride of sodium	26.22
Oxide of iron	1.75
Silica	2.06
Alumina	1.75
Potassa	trace
Total	88.68
	Cub. in.
Carbonic acid	186.35

Therapeutic Properties.—The presence of so large a proportion of carbonic-acid gas in this water, together with the oxide of iron, furnishes the latter in a very desirable form—that of the carbonate. There is no doubt but that this water will eventually prove very popular as a tonic and alterative agent.

These springs are situated in the Sierra Nevada Mountains of Eastern California, at an altitude of about seven thousand feet. Game abounds in the surrounding country. From the latest accounts no hotel had yet been erected at the springs.

G. B. F.

SUNDEW (*Drosera*, Codex Med.), *Drosera rotundifolia* Linn.; Order *Droseraceæ.*

This little plant, and others of its genus, have been used now and then for generations in medicine, generally for phthisis, and as often have fallen into neglect. They appear to contain, besides ordinary vegetable products, a peculiar acid, irritating to the skin. In common with other insectivorous plants, the glandular hairs of the leaves secrete a substance capable of dissolving albuminous substances. They have probably no medicinal value.

Allied Plants.—The most interesting plant in the order is the famous Venus Fly Trap, *Dionæa Muscipula*, of North Carolina, whose leaves close like the jaws of a steel trap upon unfortunate insects alighting on them.

W. P. Bolles.

SUPERFŒTATION. By this term we mean the impregnation of a female already pregnant. Superfœtation proper must be clearly distinguished from superimpregnation (superfecundation). Most writers admit the possibility of the latter: *i.e.*, that two ova belonging to the same period of ovulation can be fecundated during sexual intercourse practised by the same or different persons near the same period of time. This seems to be proved by that class of cases in which the same woman has given birth to twins bearing evident traces of being the offspring of fathers of different races.

Dr. Mosely tells of a negress who brought forth two children, one a negro and the other a mulatto. She said that a white man on the estate had had intercourse with her directly after her black husband had quitted her. Rev. Dr. Walsh narrates the case of a creole woman who had three children at a birth, of three different colors—white, brown, and black—with all the features of the respective classes. Fodéré, on the authority of Buffon, records the case of a woman who gave birth to twins, one being white and the other black. She confessed that immediately after her husband had left her she was forcibly raped by a negro. Dr. Nowlin reports the case of a negress who gave birth to twins, one a pure African, with all the typical features of that race, and the other a very bright mulatto, exhibiting evident characteristics of the Caucasian race. The mother was a pure black, with all the typical features of the African, as was also her husband. Upon inquiry, he ascertained from the mother that she had permitted intercourse with a white man the day succeeding the same act with her husband. Such cases seem to have been very common in slave-holding countries, and Beck gives nearly half a page to such references.

Scanzoni, who rejects even the idea of superfecundation, explains such cases on the ground that children sometimes resemble the father and sometimes the mother, both in features and complexion. In twin pregnancies one child may resemble the father and the other the mother; and it seems quite possible that all that is necessary for the production of a black child and a white one is cohabitation between a black man and a white woman, or, what is vastly more common, a white man and a black woman—one child resembling the father and the other the mother. Few, however, agree with Scanzoni in this view, and the possibility of superfecundation is pretty generally admitted, being based chiefly on what we know from comparative physiology.

On the other hand, the possibility of superfœtation has been vigorously opposed by many writers, and the evidence in its favor leaves much room for doubt. The idea implied is, that a woman who is already pregnant may, at a stage of pregnancy more or less advanced, again conceive, and carry at the same time the fruit of two conceptions between which there must be a considerable interval.

It is admitted by all that superfœtation may take place in extra-uterine pregnancy, and in cases of double uterus or bilocular uterus. An example of this is reported by Montgomery, in which, while the product of an extra-uterine pregnancy remained encysted within the abdomen, the woman bore three children. Dr. Steigervahl records a similar case, and Dr. Cliét, of Lyons, reports a very interesting one in which a woman died suddenly, and at the post-mortem examination there was found an extra-uterine fœtus of five months in the abdomen and a fœtus of three months in the uterus.

A careful analysis of the so-called cases of superfœtation shows conclusively that the phenomena in most of them can be explained by twin pregnancies. But, on the other hand, there are numerous examples advanced in support of this idea which cannot be explained by this hypothesis.

One of the arguments is based on the cases in which two living children have been born at different and widely separated periods. The following are the intervals in some of these cases: Four and a half months, Marianne Bigaud; five and a half months, Benoite Franquet; five months, a woman of Arles; seventeen

weeks, a case of Dimerbroeck; six weeks, a case of Lebas; four weeks, a case of Dr. Moebus; fifty two days, a case of Thielmann; forty-two days, cited by Fordyce Barker; one month, Giuseppe Generali (*vide* Ganahl, "Superfœtation," Paris, 1867). Supposing that two children be born at an interval of four months, and both be capable of being reared, we must acknowledge that superfœtation is probable, or admit that a five-months' child is capable of being reared, which is in the highest degree improbable.

Another argument is advanced by Dr. Bonnar, who gives a number of cases in which children born in wedlock succeeded each other with very unusual rapidity. The question of superfœtation is here looked upon from a different point, in reference more particularly to the period after parturition at which the female procreative organs are again capable of exercising their functions. He gives three cases in which there intervened between the two deliveries 182, 174, and 127 days respectively; and all the children were sufficiently developed to be reared and, without exception, to reach maturity. In the latter case, subtracting from the interval (127 days) which occurred between the two deliveries 14 days, which Dr. Bonnar assumes to be the earliest possible period at which a fresh impregnation can occur after delivery, we reduce the gestation to 113 days—that is, to less than four months. As both these children survived, the second child could not possibly have been the result of a fresh impregnation after the birth of the first; nor could the first child have been a twin prematurely delivered, for, if so, it must have reached only a little more than the fifth month, at which time its survival would have been impossible.

In regard to the objections based on the supposition that the decidua so completely fills up the uterine cavity that the passage of the spermatozoa is impossible, we may say that the decidua reflexa does not come into apposition with the decidua vera until about the eighth week of pregnancy, and, therefore, until that time there is a free space between the two membranes.

Lastly, respecting the cessation of ovulation during pregnancy, this no doubt is the rule, but there are, however, a sufficient number of well-authenticated cases of menstruation during pregnancy to prove that ovulation is not always absolutely in abeyance.

Therefore, the most reasonable conclusion seems to be that, although the vast majority of cases of so-called superfœtation can be explained by twin pregnancies, there is a small number of cases which cannot be explained upon this hypothesis, and this makes the existence of superfœtation seem probable. *Dillon Brown.*

SUSPENSION SPLINT, HODGEN'S. The value of extension in the treatment of fractures of the femur is universally conceded. The effort to obtain continuous extension with immobility has resulted in a multiplicity of methods of treatment, some of which are complicated and troublesome, others cruel and inefficient. The most simple and effective *continuous extension* is found, I think, in oblique suspension, as first advocated by Nathan R. Smith, when he introduced his anterior splint. Suspension, with the amount of traction determined by the obliquity of the suspending cord, is more easily applied and efficiently maintained in that modification of Smith's anterior splint devised and so successfully used by the late Dr. John T. Hodgen, of St. Louis, than by any other method. This splint, in the hands of an expert, secures nearly perfect immobilization, and extension so equable and effective as to give practically perfect results. The freedom of motion allowed to the patient does not interfere with immobilization of the fractured bone.

The illustration shows the splint in use, with leg suspended, as for the treatment of fractures of the thigh. The simplicity of the structure of the splint is evident, and the manner of the suspension of the leg is made plain. The leg is resting on muslin strips which pass under it. These are secured by pins at each end, after overlapping the arms D E and D′ E′ of the splint. Each strip supports its proportion of the weight of the leg. These strips extend from the heel to the gluteal fold. The adhesive strip H, softened by warmth or by turpentine, is applied to the leg, and secured in position by a roller which extends as high as the knee. This strip secures the leg in the splint, since it is fastened by the cord and block N to the foot of the splint at F.

The splint itself is composed of a single piece of No. 2 wire, bent as shown in Fig. 3746. The sliding hooks D, D′ and E, E′ are used for attaching the suspending cords to the splint. The use of the arch O is to maintain the proper width of the splint at its upper end, viz., 20 or 25 ctm. (eight or ten inches). This arch is loose, and is easily slipped over the ends of the wire which forms the splint before the latter is applied to the leg. The width of the splint at the foot is about 10 ctm. (four inches), and is determined by the bend in the wire which forms the body of the splint. The wire hooks E, E′ and D, D′ present at one end a free loop for the attachment of the supporting cord, while the other end is coiled somewhat snugly about the lateral bars of the splint (at D and E). The lateral bars, to which the muslin strips are attached, extend upward on each side of the leg, so that the two ends of the wire reach, the one to a point above the pubes, and the other, on the outside, nearly to the crest of the ilium. The bend in the splint at the knee permits slight flexion of the leg.

The distance from the foot of the splint to the bend of the knee is 56 ctm. (twenty-two inches), and from the angle to the upper free ends 50 ctm. (twenty inches). The suspending apparatus is composed of, first, the pulley A, which is fixed in a framework over the bed, or, preferably, in the ceiling; secondly, the sliding block B, and the cord B, A, C; thirdly, of the two cords D, C, E and D′, C, E′, of equal length, and with a loop at each end for attachment to the wire hooks at D, D′ and E, E′. These cords are passed through a loop in the cord at its end C. The suspension of the leg and splint is readily accomplished by sliding downward the block B on the cord B, A, C.

The splint, as stated above, is a modification of Nathan R. Smith's anterior splint, the lateral arms being substituted for the anterior wires, to which the leg in his splint was to be secured by a roller bandage. Here the leg is sustained by the muslin strips, any one of which can be readily and quickly changed so as to give increased or diminished support to any part of the leg, thus maintaining the proper outline of the bone during the rapid atrophy of the soft parts which ensues upon the enforced rest of the limb.

The extension is maintained through the adhesive strip H, which, extending from one tuberosity of the tibia to the other, across the board N at the sole of the foot, is fastened by a cord to the cross-bar at F, and thus securely holds the leg in the splint. Through this medium the extending force is transferred from the splint to the leg. The board at the sole of the foot should be as wide as the adhesive strip, and about 7 or 8 ctm. (three and one-half inches) long. It then protects the malleoli from the lateral pressure of the adhesive strips through which the extending force is applied.

The splint as shown in Fig. 3745 is cheap, and readily made by any blacksmith. The splint as represented in Fig. 3746 is more expensive, but can be adjusted to a leg of any size.

The lateral bars B and C are hollow square tubes, furnished with thumb-screws at their extremities, B, C. These tubes are of sufficient size to admit the terminal ends of the lateral bars, and by pushing in or pulling out the extremities of the lateral arms the length of the splint may be varied. Its width can also be changed by sliding the lateral arms into the hollow tube A, A, which is furnished with thumb-screws at A, A. The splint is fitted by sliding B, A and C, H to the proper point, and securing them by setting the thumb-screws at B and C. The hooks D, E, for suspending the splint, slide on the lateral bars B, C. The splint is used in the same manner as the one before described. The foot-piece P is to prevent passive extension of the foot. Its use is optional with the surgeon. Its chief utility is found in cases of compound fracture of the leg. The foot-piece here

shown is a thin board fastened to the heavy cross-wire, which is curved so that one end fits around the lateral arm of the splint, and the other is so bent as to maintain the foot-piece at its proper angle. Dr. J. Freund, of Champion, Mich., has devised a foot-piece which answers a good purpose. It is held in position by two transverse slips of wood fastened by thumb-screws, and has the inclination of the foot-piece determined by a third thumb-screw which is fixed in one of the transverse slips.

The application of the Hodgen suspension splint is simple and, in skilful hands, painless. Suppose the leg, with its fractured femur, is resting upon the bed. A roller bandage is applied to the foot and ankle, to prevent swelling, excoriation, or tenderness, from the pressure of the bandage or of the adhesive strips on the malleoli. Then

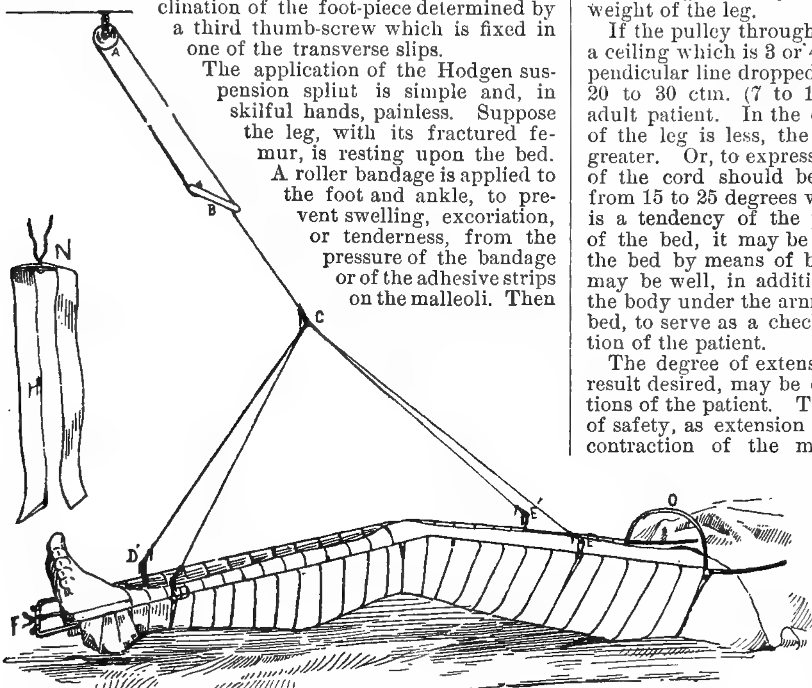
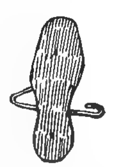


Fig. 3745.

the adhesive strip H, with its foot-piece and cord, is placed in position, an assistant grasps the foot with one hand, and, with the other hand under the knee, lifts the leg from the bed, while at the same time he makes steady extension of the femur. The surgeon then continues the application of the roller as high as the knee-joint, and thus secures more perfect adhesion of the plaster to the leg. The leg is again allowed to rest upon the bed, but the assistant maintains moderate traction on the foot, so as not to relax extension of the fractured bone while the splint is put in position. A lateral arm of the splint is placed upon either side of the leg, and the cross-bar is brought close to the sole of the foot. The cord and block N, with the adhesive strip, is now fastened to the foot of the splint. Strips of muslin are passed under the leg, one at the ankle, one at the knee, and perhaps two under the thigh. These are secured by pins to the lateral arms of the splint, while it is held with its upper end so that the inner arm is above the pubes, and its lower end is on a level with the malleoli. The leg can now be suspended by attaching the cords D E and D' E', and adjusting the slide B so as to lift the splint and leg from the bed. The cradle of cloth strips upon which the leg is to rest, is now made complete by adding strips of muslin, and adjusting them to the outline of the leg as indicated in the cut. The upper end of the wire which is to be above the pubes, may be bent upward to permit greater freedom in the movements of the body. No special or violent attempt at adjustment is made, nor is it necessary, except where there is marked lateral displacement, as in some transverse fractures. The free swinging of the leg, and the efficiency of the extending force, secure a perfect adjustment in a few hours. The fracture sets itself. The degree of extension is regulated by the obliquity of the cord and the weight of the leg.



If the pulley through which the cord passes is fixed in a ceiling which is 3 or 4 metres (9 to 12 feet) high, a perpendicular line dropped from the pulley should fall from 20 to 30 ctm. (7 to 10 inches) beyond the foot of the adult patient. In the case of a child, where the weight of the leg is less, the obliquity of the cord should be greater. Or, to express it more accurately, the obliquity of the cord should be sufficient to make an angle of from 15 to 25 degrees with the perpendicular. If there is a tendency of the patient to slide toward the foot of the bed, it may be obviated by raising the foot of the bed by means of blocks. In the case of a child it may be well, in addition, to pass a cord loosely about the body under the arms, and fasten it to the head of the bed, to serve as a check to any great change in the position of the patient.

The degree of extension necessary to accomplish the result desired, may be determined in part by the sensations of the patient. The position of comfort is the one of safety, as extension is required only to overcome the contraction of the muscles. The counter-extending force is the weight of the body. Much less extension is required in such splints as suspend the leg and remove the resistance of friction of the leg on the bed, than is required when the leg rests upon the bed, and weight and friction are first to be overcome. It is never necessary, when using this splint, to apply, in the case of an adult (as recommended by Hamilton when speaking of other methods of making extension), twenty pounds as an extending weight; or, as he states it in his work on "Fractures and Dislocations," published in 1880, "one pound for a child one year of age, two pounds for a child two years of age, and so on, adding one pound for each year up to the twentieth." An extension of twenty pounds, applied through an adhesive strip to the leg, and pulling upon the knee-joint and femur, is a serious trial to the patient's endurance, and it taxes the surgeon's ingenuity to maintain steadily such a force.

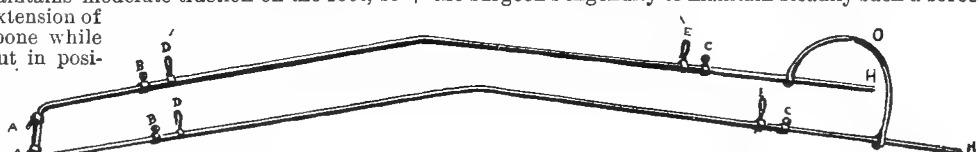


Fig. 3746.

The amount of extension required in this suspension splint is much less, being from three to ten pounds. This is all sufficient, for there is no friction to overcome, and so long as the patient maintains a position in bed approximating the one he occupied when the splint was adjusted, there is no variation in the extending force. It is quiet, persistent, non-irritating, and effective. There is no perineal band to fret and worry the patient. The extending force is determined by two factors, and these are entirely within control of the surgeon, viz., the obliquity of the extending cord, and the weight suspended. The first can be varied by the relative position of the bed and the suspending pulley, and the latter can be increased if desired by placing sand bags across the lateral bars of the splint. The weight of the leg distributes some of the extending force to each of the muslin strips

upon which it rests, and thus diminishes somewhat the traction upon the adhesive strip.

It seems difficult for some persons to understand how extension can be applied to a fractured thigh by direct traction upon the leg, without counter-extension through a perineal band. They fail to recognize the efficiency of the weight of the leg and the stability of the body, as a counter-extending force. The amount of the extending force that is transmitted through the adhesive strip in the suspension splint, may be measured by substituting a spring balance for the cord, which in the cut connects the block N with the foot of the splint. A small portion of the extending force is, however, transmitted through the strips which support the limb in its cradle, and those who wish can, by mathematical formulæ, compute the extending force.

Professor Francis E. Nipher, of the Washington University, and Dr. A. K. Worthington, used the following formulæ for determining the extending force (the line D in the diagram (Fig. 3747), represents, approximately, the line of the splint and of the femur):

The pull on the short cords, C E, and C E', and also that on C D, and C D' (see Fig. 3745), can be accurately measured. The angles *a* and *b* (Fig. 3747) can also be measured. The traction force along C E, and C E', is represented by *A*, and that along C D, and C D', by *B*.

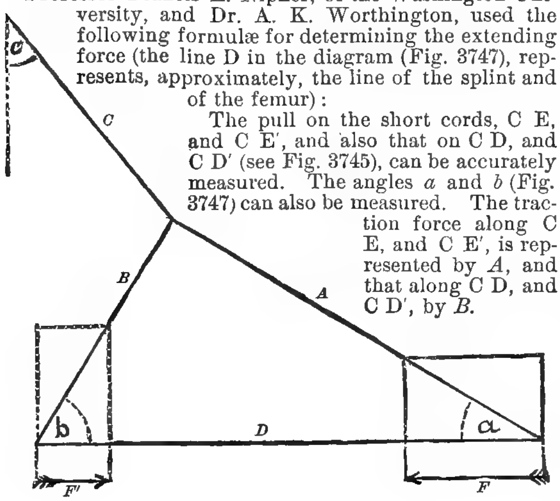


FIG. 3747.

The forces *A* and *B* being known, as also the angles *a* and *b*, we can readily calculate the horizontal components, F and F'. The resultant of F and F' will represent the direct traction force exerted along the line D; or the amount of efficient extension applied in the line of the femur.

In a particular case, where the patient weighed 150 pounds, and the suspending cord, C (or in Fig. 3747, A, B, C) formed an angle of 15° with the perpendicular:

It was found that the pull...........	A = 11.5 pounds.
and the pull.........................	B = 10.5 "
The angle............................	a = 40°.
The angle............................	b = 75°.
Hence, by trigonometry...............	F = A cos. a,
and..................................	F' = B cos. b.
Whence by substitution...............	F = 11.5 x cos. 40 = 8.8 pounds.
" "	F' = 10.5 x cos. 75 = 2.7 "
Therefore the resultant of	F and F' = 6.1 pounds.

F and F' act in different, opposing directions, hence their resultant is the difference between them, or 6.1 pounds, which represents the amount of the extending force applied to the femur in this case. If the angle C was increased to 36°, it was found:

That the angle	a = 35.
" "	b = 105,

and the force or pull on

A = 14 pounds.
B = 12.5 "

Here the forces F and F' are exerted in the same direction, since the angle *b* is greater than a right angle, and their resultant is the sum of the forces which (by the same formulæ as before) is found to be 14.7 pounds. The weight of the leg was estimated at 21 pounds.

The loop C, in the cord B, A, C (Fig. 3745), is loose and can be slipped along the cords D, C, E, and D', C, E', and the angle made by these cords with the splint should be changed with the obliquity of the suspending cord, B, A, C.

The leg is open for inspection, and the supporting strips can be readjusted as the parts atrophy. The slight natural anterior curve of the femur can be maintained. The circulation is undisturbed, the nutrition is not interfered with by the pressure of the retentive apparatus, and is as perfect as it can be during the enforced quiet. The leg can be kept cool or warm, as desired. The patient may sit up or lie down, as comfort suggests. The bed-pan can be used without disturbing the fracture, and the best possible result can be obtained, viz., no shortening and early union, without bed-sores or any of the constitutional complications which are liable to follow confinement in a fixed position.

The flexion of the knee is sufficient only to put the leg in a comfortable position, relaxing slightly the tension of the hamstring muscles and the gastrocnemius. The slight flexion of the thigh on the pelvis puts at rest the psoas and iliacus, and the rectus extensor of the thigh. The muscles are placed in a state of equilibrium.

The splint is well adapted to the treatment of all fractures of the femur, whether they are intra- or extra-capsular, through the trochanters, the shaft, or the condyles. Nor does the age of the patient interfere with its use, though a fixed dressing may be more convenient for children under six months or a year of age.

After a long and successful experience with the splint in private practice and hospital work, and after having observed its employment by the late Dr. John T. Hodgen during the last fifteen years of his life, I know of but one practical difficulty which arises in its universal and immediate use in all fractures of the femur. This objection pertains only occasionally to the fractures of the middle third of the bone in children. These exceptions are rare, extremely so, and if a perfect adjustment of the extending force to the necessity of the individual case could be obtained at once, they would be reduced to a minimum. The objection is found in the spasmodic contraction of the muscles, which at times is so frequent and violent, immediately after injury, that some lateral pressure is necessary to the comfort of the patient. This spasm may in part be controlled by lateral supports to the thigh, or by permitting the leg to rest upon the bed with extension applied after Buck's method. No form of dressing will uniformly control it. After this irritability subsides, the leg is more comfortably and more efficiently treated in the suspension splint. This clonic contraction of the muscles is more likely to be present if the extending force is in excess of the necessities of the case. The excessive tension acts as an irritant to the muscles.

Fortunately these cases are rare. Clonic contractions will, in isolated cases, occur in any splint and under any plan of treatment, for no lateral support or compression can prevent the contraction which accompanies a muscular spasm.

Opiates are sometimes useful, in the case of nervous children, for a few days after such an injury is received. The splint, and the manner of applying extension, afford the most perfect means of neutralizing the tonic contractility of the muscles, which so often determines shortening. The oblique suspension gives continuous and equable extension of an amount sufficient to accomplish a perfect result, without waste of any force, and it insures to the patient the most perfect liberty attainable by any known means compatible with comfort and safety.

H. H. Mudd.

SWEET CHALYBEATE SPRINGS. *Location and Post-office,* Sweet Chalybeate Springs, Alleghany County, Va.

ACCESS.—By the Chesapeake & Ohio Railway to Alleghany Station; thence by stage about ten miles to the springs.

THERAPEUTIC PROPERTIES.—This is a famed and valuable calcic-chalybeate water, used either as a beverage or for bathing. There are four springs, differing little in

composition. The water is sparkling, and has a sweet and ferruginous taste. It is indicated in all conditions accompanied by anæmia, chlorosis, etc.

These springs are located in the western part of Virginia, in a valley of the Alleghany Mountains, amid the beautiful scenery of that section. There are good hotel accommodations and bathing conveniences of all kinds. The flow is eight hundred gallons per minute.

ANALYSIS.—

	Grains.
Carbonate of lime	0.337
Chloride of sodium	0.011
Chloride of magnesium	0.196
Chloride of calcium	0.003
Sulphate of soda	0.404
Sulphate of magnesia	0.897
Sulphate of lime	4.110
Sesquioxide of iron	0.092
Total	6.050

Carbonic-acid gas, 13 cu. in. Temperature, 75° F.

Average temperature at hotel:

	6 A.M.	12 M.	6 P.M.
July 2 to September 5, 1870	70⅜°	84⅜°	78°
July 24 to August 19, 1871	65°	80°	78°

George B. Fowler.

SWEET SPRINGS (MO.). *Location,* Saline County, Mo.

Post-office, Brownsville, Saline County, Mo.

ACCESS.—By the Lexington Branch of the Missouri Pacific Railroad to Brownsville; thence by stage one mile to the springs.

ANALYSIS (C. P. Williams).—One gallon (231 cu. in.) contains:

	Sweet Springs. Grains.	Akesion Spring. Grains.
Chloride of sodium	86.91773	756.11398
Chloride of potassium	3.39796	28.56395
Chloride of lithium	0.04756	0.29386
Chloride of magnesium	22.29123	87.31837
Chloride of calcium	14.72127	74.79091
Carbonate of lime	9.56312	......
Carbonate of iron	0.56656	0.26683
Carbonate of manganese	0.00190	0.19911
Sulphate of lime	9.45913	.....
Bromide of magnesium	0.11802	0.13108
Magnesium nitrate	......	0.17805
Ammonium nitrate	......	1.17193
Sodium sulphite	......	2.60873
Calcium sulphite	......	57.93380
Barium sulphate	......	8.15046
Calcium phosphate	......	0.24267
Calcium carbonate	......	40.25091
Alumina	0.08921	0.16679
Silica	1.08471	0.51319
Organic matter	4.01300	3.04696
Total	152.27140	1,052.94695

THERAPEUTIC PROPERTIES.—The Sweet Spring is a mild and agreeable saline water, of efficacy in digestive and urinary disorders. The Akesion is a very strong saline, impregnated with sulphur, and is much employed as an active cathartic.

The extensive and commodious baths add greatly to the comfort and remedial value of this resort.

These springs are located in Western Missouri, on the bank of the Blackwater River. The hotel, a large building with modern appliances for convenience and comfort, stands in a well-shaded lawn of thirty acres, and, with the numerous cottages, affords the best of accommodations. The arrangements are most complete for all descriptions of baths, including two plunges, each thirty-four feet in diameter. The baths are supplied from the salt-sulphur springs, five miles distant, the water being pumped at the rate of two hundred thousand gallons per day. In addition to the above two springs there are two others, the White and the Black Sulphur, the waters of which are supplied when desired.

G. B. F.

SWEET SPRINGS (W. VA.). *Location and Post-office,* Sweet Springs, Monroe County, W. Va.

ACCESS.—By the Chesapeake & Ohio Railroad to Alleghany Station; thence by stage ten miles to the springs.

ANALYSIS.—One pint contains:

	Grains.
Carbonate of magnesia	0.103
Carbonate of lime	3.757
Chloride of sodium	0.017
Chloride of magnesium	0.039
Chloride of calcium	0.018
Sulphate of soda	0.793
Sulphate of magnesia	1.174
Sulphate of lime	1.646
Peroxide of iron	0.018
Iodine	trace
Earthy phosphates	trace
Silica	0.021
Total	7.586
	Cub. in.
Carbonic-acid gas	11

THERAPEUTIC PROPERTIES.—These are well-known and valuable calcic waters. Their natural temperature is about 75° F., which renders them very popular as baths. The contained carbonic-acid gas and the slightly sweetish taste (common to calcic waters) induce one to drink of the waters freely, and thus diuresis and mild catharsis is promoted. We are of the belief that their value in gravel, dyspepsia, and sterility is due chiefly to the quantity which one is able to take, thereby establishing a physiological condition of the secretive organs, rather than to any contained ingredients.

These springs are located in a beautiful valley, between the Alleghany and Sweet Springs Mountains, at an elevation of two thousand feet above the sea. The surrounding country is charming, and affords numerous delightful drives and walks to many points of interest. The hotel and cottages, built of brick, afford first-class accommodations for eight hundred guests.

The bath-house is arranged to supply hot and cold baths, of either mineral or pure water, and contains two large plunges, about sixty by thirty feet. The flow of the springs is eight hundred gallons per minute.

G. B. F.

SYCOSIS, sometimes called sycosis non-parasitica, to distinguish it from tinea sycosis, is a chronic inflammatory, non-contagious disease of the skin, involving the hair-follicles, characterized by the formation of pustules, papules, and tubercles, which are perforated by hairs. The subjective sensations are burning and itching. The disease is confined to the beard and hairy parts of the face. Papules and then pustules form, each one having a hair as its centre, and showing little inclination to rupture. The pustules are generally discrete, but are sometimes so numerous as to be crowded together. They are accompanied by marked redness of the surrounding skin, sometimes by swelling, burning, and pain. Unless the suppuration is profuse, the hairs cannot be extracted without giving much pain. The cause of the disease is not known. It sometimes, however, occurs on the upper lip, following nasal catarrh. It occurs equally in those who shave and in those who do not. The disease is essentially an inflammation of the hair-follicles. In the early stages the hairs are firm in their follicles, but when there has been a good deal of suppuration they become loose and may be pulled out. A cicatrix, with baldness, is then apt to result.

Sycosis is apt to be mistaken for eczema of the beard, and more especially for tinea sycosis, or true barber's itch. From the latter it is, however, distinguished by several marked characteristics. In both affections the hair-follicles are attacked; but in the parasitic disease the lesions are simply large, rounded red lumps, or nodules of various sizes, with few or no pustules. The hairs, however, in spite of the fact that there is no suppuration about their roots, come away easily, and sometimes drop out spontaneously. The discovery of the spores of the vegetable parasite in the roots of the diseased hairs, when looked for under the microscope, will greatly aid in the diagnosis. (See under Tinea.) From eczema of the beard, sycosis is distinguished by the absence of oozing or itching, and also by the fact that eczema rarely attacks the beard without showing itself elsewhere. It spreads about in crusts and pustules in the neighborhood, while sycosis is

strictly marked by discrete pustules, each with its hair running through the centre.

External treatment is that most generally useful in sycosis. Exposure to irritating influences is to be avoided. The hair should be kept clipped close or shaved. The latter is to be preferred. Although painful at first, it is in some cases absolutely necessary, if a favorable result is to be reached, that shaving should be practised every second or third day, according to the rapidity with which the beard grows. When shaving is to be performed for the first time, the hairs should be clipped close, and then a poultice should be applied to soften the crusts. After such careful preparation, the use of the razor is much less painful than it would otherwise have been. Shaving having been established as a habit, the local medical treatment may be begun. When the disease is acute, and there is a good deal of pain and swelling, black wash may be thoroughly applied every two or three hours, followed each time, so soon as the skin is dry, by oxide of zinc ointment, gently applied by means of the finger, or spread upon soft linen and bound upon the parts.

The following wash, not to be followed by ointment, is likewise of service in acute sycosis: ℞. Pulv. zinci carb. precip., pulv. zinc. ox., āā 4 Gm. (ʒ j.); glycerinæ, 8 Gm. (ʒ ij.); liq. plumbi subacetat. dil., 8 Gm. (ʒ ij.); aquæ rosæ, 240 Gm. (℥ vijss.). M.

In subacute cases the following wash is very good: ℞. Sulphur. precipitat., 8 Gm. (ʒ ij.); pulv. camphoræ, 0.65 Gm. (gr. x.); pulv. tragacanth, 1.3 Gm. (℈ j.); aquæ calcis, 128 Gm. (℥ iv.). M. Shake well, and apply from two to four times a day. If ointments are to be employed, the following will be found soothing in the acute stage: ℞. Pulv. zinc. carb. precip., pulv. zinci ox., āā 4 Gm. (ʒ j.); ung. aq. rosæ, 32 Gm. (℥ j.). M. To be applied immediately after shaving. Another convenient ointment, slightly more stimulating, is composed of 1 part of calomel to 32 parts of oxide of zinc ointment.

When the affection is of long standing, and when there is much infiltration, sapo viridis should be well rubbed in with a flannel rag and a little water, then washed off, and finally diachylon ointment should be applied. Depilation is to be used only when the roots of the hairs are loosened by suppuration.

The prognosis in sycosis should be guarded, for while some cases yield readily to treatment, others, particularly when the disease involves a considerable area of the face, last for months and even years. In spite of the most assiduous attention, relapses are not uncommon.

Arthur Van Harlingen.

SYMPATHETIC NERVOUS SYSTEM, DISORDERS OF THE. Under this heading it is mainly intended to discuss the grounds for and against the commonly accepted opinions as to the origin of certain troubles being due to disorders (functional or organic) of the sympathetic system of nerves.

Although the physiology of the sympathetic has been advanced considerably within recent years, there has not been a commensurate advance in our knowledge of its diseases.

In fact, with the exception of a few important symptoms which we know to have a direct causal connection with alterations in the sympathetic, our knowledge of its diseases is very superficial and in many cases purely problematical.

Of the many diseases that are attributed to changes or alterations in the sympathetic, the following are the chief: Hemicrania, exophthalmic goitre, angina pectoris, Addison's disease, diabetes mellitus, unilateral hyperidrosis, glaucoma, neuro-retinitis, ophthalmia neuro-paralytica, etc.

Hemicrania or Migraine.—In 1860 Du Bois-Reymond noticed, while suffering from an attack of migraine, that the temporal artery on the affected side was hard and cord-like to the touch, that the face on the same side was pale, and the eye retracted and injected.

During the decline of the attack the ear on the affected side became warm and red. He concluded that the cause of the attack was a tetanic contraction of the coats of the vessels on the affected side of the head.

It is impossible to account for this spastic contraction on any other grounds than that there is an affection of the sympathetic or of its medullary centre. Du Bois-Reymond looked upon this spastic contraction as the fundamental cause of the terrible pain present in these cases. He compares the pain to that of uterine pain in labor, and considers that it is due to pressure on the nerves of sensation in the muscular tissue.

The above views so ably put forward by their distinguished originator are, however, entirely inadequate to a proper explanation of the origin and course of a true migrainous attack.

I think it must be admitted that true migraine is an essential neurosis—that it is, in fact, due to a discharge from the sensory area of the brain, "or in that part of the sensory area which is the anatomical correlative of the sensation of pain in the head." [1]

The discharge is seldom, however, entirely limited to the sensory area of the brain, but is found to extend to other parts. Frequently it extends to the medulla, especially to the vaso-motor centre. It is in this way that the vaso-motor phenomena are more truly explained. The discharge may involve the cilio-spinal region and in this way cause the oculo-pupillary phenomena occasionally seen during an attack.

It will be seen, therefore, that the phenomena of sympathetic disorder present in migraine are only a result, and that only occasionally, of deeper-seated change. It is, therefore, according to this view, incorrect to speak of migraine being a disorder of the sympathetic system. Further, it is only on this view that a satisfactory explanation can be given of migraine.

Exophthalmic Goitre.—In spite of the able and persistent attempts made to explain the phenomena of exophthalmic goitre by attributing them to changes in the sympathetic, we are at the present time further away than ever from accepting such an explanation. At first sight it appears to be comparatively easy to explain wholly and completely the remarkable triad of symptoms by referring them to lesions of the sympathetic system, but, on deeper examination of many reported cases, it will be at once apparent that this cannot be the true explanation of this affection.

Very numerous opinions have been advanced at different times as to the nature of this disease, at first attributed to deficiency of the cellular elements of the blood, and afterward to organic lesions of the heart.

Laycock was the first to include the disease among the pure neuroses. Trousseau was the first to maintain its sympathetic origin.

To discuss this subject fully, it will be necessary to deal with the symptoms individually.

We will first treat of the cardiac palpitation, which is an essential symptom. It is always present. The other symptoms may be each and *all* absent, and still we may have to do with exophthalmic goitre. They may all be present, but unless there is a greatly increased cardiac action accompanying them, then we have not to do with exophthalmic goitre. To account for this increased cardiac action, irritation of the accelerator fibres running in the sympathetic has been assumed, and to explain the dilated condition of the thyroid vessels, a paresis of the vaso-motor fibres running in the sympathetic had to be supposed. We are asked to believe that one and the same change brings about two distinctly opposite effects; viz., paralysis of one set of fibres (vaso-motor) and irritation of another set (accelerator). This is certainly highly improbable, but what is contrary to all sound physiological principles is, that any one set of fibres can remain in a constant state of irritation for many months or even for many years.

Friedreich interprets the palpitation as being due to a paralysis of those vaso-motor fibres which supply the coronary arteries, and in this way leading to more blood being sent to the muscular tissue, and consequently to increased vigor of its ganglia. The unstable heart of the exophthalmic patients points to poverty of blood-supply

rather than to an excess. We therefore see, no matter on what grounds the sympathetic origin of the circulatory derangements present in this disease is attempted to be explained, that they are entirely inadequate.

If, then, the essential symptom of the disease be unexplainable by supposing a sympathetic lesion, it is unlikely, indeed, that the disease can be brought about by such a lesion.

The exophthalmos is no doubt due to various causes, increased fat in the cellular tissue of the orbit being one of these. This has been proved in a number of instances at the post-mortem examination.

Those who contend for the purely sympathetic origin of this disease consider that the exophthalmos is principally caused by contraction of the muscles of Mueller, induced by irritation of the cervical sympathetic.

As a proof of the very unsettled state of our knowledge of the nature of this affection, it is enough to say that other writers have attributed the loss of consentaneous movement between the globe of the eye and its lid to paresis of Mueller's fibres.

If exophthalmic goitre were really an affection of the sympathetic, we would expect to find changes in this nerve in fatal cases. Although, in a few of the recorded cases, changes have been found, *post mortem*, in the cervical sympathetic and its ganglia, there has been no constant relation between the severity of the symptoms present during life and the extent of the changes after death. Even coarse lesions of this nerve and its ganglia have been found in cases where, during life, there has been no suspicion of any exophthalmic goitre. Again, in well-marked cases of the disease, no changes have been found by such competent observers as Recklinghausen, Wilks, Paul, Ranvier, and Ross.

One strong reason for thinking that the essential cause of the affection is elsewhere than in the sympathetic is the absence of any pupillary changes. It is hardly possible to conceive of great changes in the trunk of the sympathetic without changes in the size of the pupil.

There are facts of a positive character which point strongly to the central nervous system as being the seat, at least, of the principal and initial changes.

Filehne has produced protrusion of the eyeballs, enlargement of the thyroid gland, and increased action of the heart in rabbits by wounding the restiform bodies.

The rather frequent occurrence of glycosuria, and even diabetes, points also in the direction of the central origin of the trouble. So also do tremor and the extreme restlessness and sleeplessness which are frequent symptoms. Insanity in various degrees is also corroborative of this view, and, lastly, may be mentioned cases of this disease complicated by ophthalmoplegia externa. There is, for instance, the well-known case of Warner and Bristowe, where, in addition to ophthalmoplegia externa, there was bilateral paresis of the seventh and fifth nerves, and tremor of the legs. Another strong clinical argument for the central origin of this disease is that, at times, it has been seen complicating progressive muscular atrophy—accompanying this disease as does bulbar paralysis.

The evidence adduced is, I believe, sufficient to prove that the cause of exophthalmic goitre is due to certain changes in the medulla. These changes principally affect the vaso-motor centre. What their precise nature may be is unknown.

Jendrassik [2] maintains that they are of an inflammatory nature. He considers that exophthalmic goitre is due to a polio-myelencephalitis.

Unilateral Progressive Atrophy of the Face.—There are several cases on record where undoubtedly this disease was directly due to some injury of the sympathetic in the neck. The vaso-motor and trophic fibres of the face run in the sympathetic before passing to the trigeminus. In addition to the face-atrophy in the cases above referred to, there were present symptoms indicating injury of the oculo-pupillary branches of the sympathetic also. The majority of these cases are, however, due to disease of the nucleus of the fifth, or to direct injury of the nerve itself after it has received the vaso-motor and trophic fibres for the face.

Angina Pectoris.—In the present state of our knowledge of the nature of angina pectoris it is impossible to say to what extent the sympathetic is involved. There are, no doubt, many instances of this disease where the symptoms present are, at any rate partly, due to disturbances of the sympathetic, but whether this disturbance is primary or secondary we are unable to say. It is common to describe an "angina pectoris vaso-motoria;" that is, an angina due to irritation of the vaso-motor nerves. This irritation leads to contraction of the arterioles, and consequently greatly increases the work of the ventricles. The resistance to the passage of blood may be so great as to bring about acute cardiac starvation, and consequently lead to an attack of true angina.

Probably, however, the strongest evidence that we have of the reality of a true vaso-motor angina is the result obtained by the action of drugs. It is an every-day observation that the nitrites, which quickly dilate the arterioles, rapidly relieve an attack, or prevent it from coming on.

We, however, are entirely ignorant of the way in which this special vaso-motor irritation is brought about.

Addison's Disease.—In a number of cases of Addison's disease there have been found extensive pathological changes in the abdominal plexuses of the sympathetic as well as in the suprarenal capsules. On the other hand, we have quite a number of post-mortem records of this disease where the sympathetic was perfectly normal. This represents our present knowledge of this subject; and it is too scanty to lead to any definite conclusion. Even if we had positive information as to the primary origin of the changes in the sympathetic, we would be unable to explain the connection between them and the symptoms of the disease.

Unilateral Hyperidrosis.—This may occur alone or as one of a group of symptoms. As the latter it is occasionally seen in exophthalmic goitre, diabetes mellitus, tabes dorsalis, and in general paralysis of the insane. It may be limited to the neck and face, or it may involve the whole of one side of the body. It is highly probable that this symptom is owing to a lesion of the sympathetic itself or of its medullary or spinal centres.

Diabetes Mellitus.—Notwithstanding the length of time that the clinical features of this disease have been known, we have as yet no adequate explanation of its true nature. Many and varied have been the offered explanations. An explanation which at times has received much support is the one attributing the fundamental cause to changes in the sympathetic. It is well known that we can induce diabetes experimentally by irritating what is called the "diabetic area" in the floor of the fourth ventricle. This area corresponds with the chief vaso-motor centre. Sugar may also be made to appear in the urine by irritating the sympathetic in the neck, or in any part of its course above the tenth rib. In these situations the sympathetic contains the vaso-motor fibres for the vessels of the liver.

Such experimentally induced glycosuria gradually disappears entirely, even when the cause that induced it is still in operation. That occasionally a temporary glycosuria may be induced in man by irritation of the sympathetic, where it contains the vaso-motor fibres of the liver, is highly probable. It is, however, as highly improbable that a true (essential) diabetes can be due to any such changes.

James Stewart.

[1] Hughlings Jackson: The Lancet, 1875, vol. ii., p. 244.
[2] Archiv für Psychiatrie und Nervenkrankheiten, Band xvii., Heft ii.

SYMPATHETIC OPHTHALMITIS is an inflammation of one eye caused by a pre-existing inflammation in the other. It is therefore a secondary process in a previously healthy organ, induced wholly by a diseased condition in the corresponding but distant organ.

In the vast majority of cases the primary cause is a traumatism inflicted upon the first eye, which is followed by an inflammation usually somewhat prolonged. After a period varying from a few days to years, this is followed by an inflammation in the other eye, and it is to this that the designation sympathetic is given.

The first definite or accurate description of the disease was given in 1844,* by Dr. Wm. Mackenzie, the Glasgow ophthalmologist, who, adopting the pathological views reigning at that time, called it reflex or sympathetic ophthalmia, thus distinctly claiming for it a nervous character. This view has been almost universally held until within a couple of years past, when the bacteriological investigators have invaded this, as they have gradually almost every other, field in pathology, and there are now quite pronounced differences of opinion concerning the nature of the affection.

Whatever views may finally be accepted as to the pathogenesis of the disease, the clinical picture, as originally drawn, must be regarded as a remarkable instance of the result of keen observation and accurate deduction on the part of the great Scotch surgeon; and although since his time, as a result of the study of additional cases, our knowledge has increased, and we now know more of the complications which may arise and of the individual differences which may present themselves, still the important fact remains established, that a pronounced and usually fatal inflammation may arise in one eye as the direct consequence of an inflammation of its fellow.

The recent report of a collective investigation committee, appointed by the Ophthalmological Society of the United Kingdom, has added much to our practical knowledge of the subject; 211 cases (of which 131 were until then unpublished) were reported upon with various degrees of fulness, and I shall refer to that report with great freedom as the principal source of information in the compilation of this article; and the statistics there presented may be taken as representing about the proportions usually met with.

As has been stated, a direct traumatism is in the vast majority of cases the cause of the primary inflammation, and in 179 of the above cases this was distinctly the case. It was early noticed by Mackenzie that penetrating wounds in the ciliary region, involving in the cicatrix the iris, ciliary processes, or ciliary muscle, were especially liable to excite sympathetic ophthalmitis, and this report shows that in 100 cases it was distinctly mentioned, and in a certain proportion of 74 others this must have been the case, though for want of definite statements the exact number cannot be determined. In 21 others, an old perforating ulcer (presumably non-traumatic in origin) with phthisis bulbi was ascribed as the cause; in one a foreign body lodged for a long time undiscovered in the orbit; and in one there was irritation from an artificial eye occurring fifteen years after the enucleation of the globe. Several cases are reported in which the sympathetic ophthalmitis did not appear until after the enucleation of the eye first injured, and the question is thus presented whether it may not have been caused by the operation of enucleation, undertaken really as a therapeutic measure. In but seven cases was a spontaneous non-perforating inflammatory process stated directly to be the cause of the sympathetic disease, and these were all diagnosticated as spontaneous chronic irido-choroiditis. I have included among the traumatic cases six cases of glaucoma with iridectomy, in five of which the lesion in the fellow-eye presented the character of sympathetic ophthalmitis, not glaucoma—which, however, it has been asserted may by itself be truly sympathetic.

This report does not give a separate table of cases having foreign bodies remaining in the eye as a cause of the sympathetic disease, nor do the histories allow me to make one; it is to be inferred, however, in a large number; and the experience of ophthalmologists has always been that this is an especially dangerous condition, and more dangerous as the foreign body lies upon or approaches the ciliary region. This is *par excellence* the dangerous locality.

* Hirshberg has called attention to the fact that v. Ammon in 1835, in an essay on iritis, calls direct attention to a sympathetic iritis following a traumatic iritis of the other eye, and reports two cases, closing as follows: "The intimate sympathy of both eyes when disease is thus fully proved, making it the duty of the oculist, in cases of traumatic iritis of one eye, to pay the closest attention to the iris of the other, in order to detect at the outset sympathetic inflammation, by which the eye is liable to be lost." V. Ammon's essay is in Latin, I follow Hirshberg's translation.

Penetrating wounds in which the iris becomes included in the cicatrix, even when made intentionally by the surgeon, as in the operation for iridodesis, have so frequently had this unfortunate result, that the operation has, in a great measure, been abandoned as unjustifiable. Other operations in which a hernia of the iris is accidentally formed, as cataract extractions and even lacerations of false pupillary membranes following cataract extractions, by dragging upon the ciliary muscle and processes, have set up sympathetic trouble.

The form in which the sympathetic affection first shows itself is nearly always an inflammation of the uveal tract; it may be a simple plastic or a serous iritis, an irido-cyclitis, an irido-keratitis, or an irido-choroiditis. Exceptionally cases are reported in which the first distinct lesion is a neuritis, a neuro-retinitis, or a simple retinitis. Mackenzie, writing in pre-ophthalmoscopic times, and judging from the symptoms alone, believed the sympathetic lesion to be a retinitis, followed rapidly or accompanied by an iritis; but we now know that this is the exception, that the retina is not the part first affected, and that also, in a certain limited number of instances in which the disease runs a mild course, it escapes altogether. In later days it has been asserted that a true sympathetic glaucoma may exist.

The course of the inflammation in the injured eye (the excitor) presents no characteristic features different from those which we might expect to follow the injury, to indicate that it is to be followed by sympathetic ophthalmitis. It would be but a repetition of descriptions already given in the article on injuries of the eye, to describe the various courses of the inflammation which may follow the injury in the first eye; we have here to do only with the course of the sympathetic ophthalmitis. This much, however, may be said, that a violent suppurative inflammation (a panophthalmitis) is not so likely to cause sympathetic ophthalmitis as one of a milder and more chronic type. Indeed, von Graefe at one time advised exciting this form of inflammation, rather than allowing it to take the more chronic course with its attendant dangers. A more extended experience has since shown, however, that this advice is injudicious. In the present state of our knowledge we can simply say, that a sympathetic ophthalmitis is liable to follow an inflammation in the other eye presenting certain features. For example, the injured eye is the seat of frequently recurring attacks of an inflammation of a rather mild type, excited by no seemingly sufficient extrinsic cause. There is an area, often so small that it can be detected only by the touch of a blunt probe, which is the seat of very pronounced tenderness, and this area usually widens out with each recurring exacerbation of the inflammation. After this condition has existed for a variable period, usually of from a month to a year, the fellow-eye is liable to show symptoms that are now recognized as indicating that a morbid process has begun in it.

The time at which the symptoms may first show themselves in the second eye is, however, liable to greater variations than those reported in reply to the questions of the committee above referred to; the shortest and longest intervals were asked for, and, excluding "anomalous" or doubtful cases, they report eighteen in which the interval was less than four weeks, therefore to be regarded as short, and in four it was less than two weeks.

The longest period is more difficult of determination, as new injuries or inflammations, independent of the original injury, so frequently complicate the course of the disease that an exact statement is often impossible; excluding, however, doubtful or anomalous cases, in ten at least one year had elapsed between the injury and the first symptoms in the fellow-eye; but the literature is full of cases in which the period of immunity extended from ten to twenty years, and still longer periods. In many cases the injured eye was wholly lost and there had been no evidence of inflammation for a long time, and the symptoms in the fellow-eye started up without any recognized cause. In cases in which the fellow-eye is attacked while the injured eye is still in a condition of inflammation, it occasionally happens that the patient

and surgeon assert that they are able to refer the cause of the sympathetic attack to early use of the eyes, to exposure to bright light, etc. Mackenzie charges the disease directly to too early or excessive use of the injured eye. This, however, cannot hold good for those cases in which the fellow-eye is not affected until several years have elapsed after the injury, a period of perfect quiescence having passed over in the interim ; it is quite probable that the use of the eye has little to do with the sympathetic disease. The periods of quiescence in the remaining traumatic cases in the above report, varied between one and a half and twenty years, and this agrees with the experience of ophthalmologists in general, and means that no limit can positively be set to the period during which these sympathetic symptoms may not arise. In some cases mentioned in the report and elsewhere, secondary degenerative changes, especially calcification or ossification of the choroid, are given as the exciting cause of the sympathetic disease.

There are at present two prevailing opinions concerning the pathology of the affection. One is a development of Mackenzie's opinion of the nervous character, but instead of asserting that it is propagated through the optic nerve, this theory regards the ciliary nerves as the medium of transference. The other view is that the inflammation in the second eye is due to the presence of bacteria, which have penetrated it through the peri-vascular lymphatic system of the optic nerve. The former was the view almost universally held fifteen or twenty years ago, when the school of von Graefe was at its most brilliant epoch ; the latter is now advocated by his favorite pupil and successor, Schweigger, by Deutschman, Alt, Leber, Mooren, and many others.

As already stated, the sympathetic manifestation may occur under different forms, and in just so far does the symptomatology differ, so that a detailed description of all the clinical features must be but a description of these different, but at the same time allied, diseases; to avoid unnecessary repetition, therefore, reference is made to diseases of the iris, and uveal tract, and to diseases of the optic nerve and retina. It is necessary, however, to appreciate clinically two general classes, or stages, that of irritation, and that of actual inflammation. In its lightest form the sympathetic manifestation may be simply an irritation or an irritability on use,—a certain intolerance of light, a slight pain or weariness after reading, etc., a difficulty in fixing the eyes intently on a small object—in other words a weakness of the accommodation ; in addition there is a trifling and transitory redness of the circumcorneal conjunctiva. In other cases the intolerance of light may have amounted to entire disuse of the eyes (Donders) for many years, and yet no structural changes may have taken place, as shown by complete recovery of vision on the adoption of the proper treatment. These cases, however, of long-continued sympathetic irritation are of the rarest occurrence, and it is perhaps incorrect to include them in an article on sympathetic ophthalmitis, which of course means an inflammation with organic changes. Some writers have taken that position, but it is of the utmost clinical importance to understand that there is an initiative or premonitory stage (in these cases unduly prolonged) of a most obstinate disease, which, if recognized early, may perhaps be successfully treated ; while if this initial stage be allowed to pass on to the development of actual lesions, the result, in a very large proportion of cases, is a permanent and great impairment of vision, often total blindness. This initiative stage usually lasts but a short time, a few days or perhaps weeks, and it is quite possible that it is not thought of by the patients until impairment of vision or other decided evidences of inflammation, such as pain and redness, disturb them. An examination at this time will usually show unmistakable evidences of an iritis, the discoloration and contracted pupil being associated early with posterior synechia and blocking up of the posterior chamber. If these evidences of more advanced disease be not present, palpation, either through the closed lids with the finger, or more directly with a probe or other blunt instrument over the ciliary region, will usually show that there is a point of extreme tenderness from which the pain radiates to the rest of the globe. The statement has been made (Bowman) that this point corresponds exactly with the focus of most intense inflammation in the other eye, *i.e.*, the incision in a penetrating wound, or the entanglement of the iris and ciliary body after an operation, or the seat of the lodgement of the foreign body in the ciliary region.

The progress of the sympathetic inflammation is usually rapid and intractable to the action of remedies ; the iris fails to respond to the action of any mydriatic, the pupil becomes occluded, the posterior chamber becomes filled with plastic lymph, and the iris bulges forward at the periphery, while the pupillary edge remains adherent to the lens. The contraction of the plastic lymph effused behind the iris, over the ciliary body, and behind the lens, drags upon and separates the retina from its attachment to the choroid, lymph is effused behind it also, and it finally presents nothing but a funnel-shaped cord, extending from the optic nerve to the posterior surface of the lens. At first the globe is harder, but later, on the approach of the fatal changes, the tension diminishes, and the atrophic condition of all the interior structures is shown in the collapse, with depressions at the insertions of the recti muscles, which afterward takes place.

Sometimes the inflammation extends from the iris to the lining membrane of the posterior surface of the cornea (Descemetitis), even involving the corneal tissue proper. Lymph is deposited in more or less distinctly isolated spots (keratitis punctata), giving a mottled or dotted appearance as seen by oblique illumination. Some authors (Reindorf) describe a form of obstinate ulcerative keratitis, the ulcers which are scattered through the cornea first healing and then breaking out again, leading finally to perforations, and the eye is lost by the formation of a staphyloma of the cornea, or an irido-choroiditis with consecutive glaucoma.

Another form has been described by Warlomont and Testlin, under the title of serous iritis, coming on later than the plastic form and of slower course. "It does not affect the uveal track until after it has attacked the deeper parts. The symptoms are a contraction of the visual field, a medium dilatation and sluggishness of the pupil, and a progressive diminution of the acuity of vision. The globe becomes hard, the iris is discolored, the optic nerve excavated, and opacities form in the vitreous body. The posterior surface of the iris becomes covered with an exudation (of lymph), and filiform posterior synechiæ are produced." This is, however, a very clear picture of a glaucomatous process.

For some time after the invention of the ophthalmoscope and the consequent accessibility of the retina and optic nerve to direct observation, the opinion became quite general that Mackenzie's view of the neuro-retinal beginning in the fellow-eye was erroneous, but that the first sympathetic lesion was always in some part of the uveal track, as above mentioned. The methodical use of the ophthalmoscope in later years, however, has shown the occurrence of an initial neuro-retinitis in a much larger proportion of cases than was formerly supposed. Excluding all cases in which the retinitis could be regarded as secondary to an inflammation of any part of the uveal track (of the second eye), the statistics of the committee above referred to give about four per cent. of cases of initial neuro-retinitis in the sympathetic disease. These are all cases in which the vision was decidedly affected, and for the relief of which the patient applied to the surgeon. The percentage would be considerably increased if all cases were examined with the ophthalmoscope, irrespective of symptoms. Cases are reported in which a papillitis appears without failure of vision or other subjective symptoms, and after remaining a short period disappears again, leaving no traces. The course of the disease is sometimes an extension to the choroid and iris, with the same marked tendency to contraction in the effused lymph that is so noticeable when the process begins in the iris, etc., and in the worst cases with similar results. Judging, however, from the somewhat limited number of cases reported, it would appear that

this form of inflammation is by no means so severe as when the anterior segment of the globe is first affected; for, of the seven cases reported by the above-mentioned committee, two recovered with perfect vision, one with vision "not perfect," two with $V = \frac{6}{10}$, one with $V = \frac{3}{10}$, and in but one was vision totally lost—certainly better results than we expect to obtain in the usual form of the disease; and reports from other sources give similar results. Gepner, of Warsaw, reports an unusual case of intermittent sympathetic retinitis, coming on some three months after the injury, in which a distinct but transitory œdema of the retina was seen by the ophthalmoscope, accompanied by an amblyopia of $\frac{20}{200}$ (0.1), but all of which entirely disappeared in the course of a few hours, with a return of $V = 1$. The condition was observed by the surgeon twice—but it had existed for about two weeks before coming under observation. After the enucleation of the wounded eye the sympathetic trouble ceased entirely, and the vision remained perfect for several years, as long as the patient was under observation.

Ever since von Graefe, in 1857, described a "sympathetic amaurosis with excavation of the optic nerve" (following a spontaneous irido-choroiditis), cases have from time to time been described as "sympathetic glaucoma." Subjected to a critical analysis, however, most of them turn out to be consecutive glaucoma, the attack (of glaucoma) in the second eye following usually with a *very short* interval the operation of iridectomy made for a glaucoma of the primarily affected eye. This is not what should be understood by sympathetic disease, as has been well shown by Mauthner, Schweigger, Maats, and others. Neither are we justified in calling the condition a sympathetic glaucoma, when an eye, which has been for a considerable length of time affected with a recognized form of sympathetic trouble, such as serous iritis or irido-choroiditis, becomes glaucomatous, with plus tension and other evidences of increased inflammatory action. If the glaucoma were truly sympathetic, it should occur at the usual time after an injury to the other eye in which traumatic inflammation had been excited, and should be true glaucoma, and not merely a glaucomatous degeneration engrafted upon a preceding sympathetic inflammation. Furthermore, it should respond to the ordinary treatment of sympathetic trouble, viz., enucleation of the other eye, and not to that for ordinary glaucoma, namely, iridectomy on the eye affected. Unfortunately for the determination of this question, the surgeon, feeling the importance of leaving nothing untried for the relief of so imminent a danger to his patient's vision, carries out the enucleation of the excitor and the iridectomy on the sympathizer at one sitting, so that it is impossible to say to which the good result, if it occur, be due. Nevertheless, the facts observed in certain cases of Webster and Agnew, and of Dobrowolsky, lend considerable weight to the glaucomatous interpretation. These and other cases, such as those of Camuset and Krachner, of sympathetic cataract, and of Barbier, Krause, and von Graefe, of choroiditis disseminata, in which the history points apparently very positively to the sympathetic origin, must be classed among the very exceptional cases to which the explanation usually given of the pathology does not apply, and which seems to show that we have not yet demonstrated all the channels for the transmission of sympathetic disease.

Mackenzie's interpretation of the symptomatology was that it was a "reflex" inflammation, carried from the injured to the sound eye directly along the optic nerve; therefore that it was primarily a neuro-retinitis in the fellow-eye. This remained the general opinion until the discovery of the ophthalmoscope, bringing the fundus of the eye directly under observation, showed that the posterior segment of the globe was quite free from disease, at least so long as the media remained clear enough to allow it to be seen, and that the initial evidences of disease were confined to the anterior segment. Confirmatory of this ocular demonstration as to the non-participation of the optic nerve, an accurate study of the clinical phenomena soon showed that instead of this being the nerve along which the disease travelled, the ciliary nerves throughout were the medium of conduction of the sympathetic trouble. The organs or tissues to which the corresponding nerves are distributed are the seats of the initial lesions in the fellow-eye; the nerves are presumably the means of communication to it. The clinical evidence already recited seems to be quite complete; the view has received the almost universal acceptance of the profession, and the results of therapeutical procedures based upon this view confirm it.

The interpretation of clinical phenomena is, of course, a speculation based upon evidence which must in legal phraseology be designated as circumstantial, and must always be open to the admission of new facts, as new cases or new methods of investigation are brought to bear upon it. As previously stated, investigations in bacteriology have made this, the isolated example of an asserted "sympathetic" inflammation, the object of considerable study, with the result of establishing a possibility amounting, they claim, to proof, that there is an infectious element (micro-organism) concerned in the propagation of the disease. To exactly what extent the bacteria are related to the disease, whether they are essential to the production of the various phenomena observed, or whether their presence be simply accidental and of no importance, are, however, points which are still to be regarded as *sub judice*.

Deutschmann, in a series of experiments extending over several years, has studied the effects upon the fellow-eye of the introduction of micro-organisms and of irritating substances into the vitreous body and into the optic nerve-sheath. His experiments were all made upon rabbits, and he gives the following as the results of his investigations: 1. The injection of aspergillus, of croton-oil, or of staphylococcus aureus and albus, was uniformly followed by papillitis, neuro-retinitis, and choroiditis of the fellow-eye; 2, the process can be traced by post-mortem examination along the sheath of the nerve, starting from the seat of the injury; 3, in the case of the bacteria, similar organisms to those injected, and those only, are found in the secondary lesions. The progress of transmission from one eye to the other is a matter of several weeks, though the amount and the strength of the injection (depending upon the dilution of the injected fluid with a saline solution) influence greatly the rapidity of the transmission.

Besides the experimentally excited sympathetic disease, Deutschman also reports the results of examinations of eyes which had caused sympathetic inflammation in their fellows, and which had been enucleated as a therapeutic measure. In all he found micro-organisms and the extension of inflammation along the nerve and sheath as far as the specimen allowed examination. He thinks it probable that there are various micro-organisms capable of producing sympathetic ophthalmitis; in other words, that it is not a specific inflammation. In answer to the objection that purulent micro-organisms usually excite an acute (virulent) process, he denies that this is constantly the case, and cites an instance of experimental disease in a rabbit inoculated with a culture fluid of staphylococcus albus, obtained from the anterior chamber of a patient suffering from sympathetic ophthalmitis. At the end of five weeks the rabbit's eye showed beginning atrophy of the optic nerve, an opaque white disk, strikingly narrowed vessels, atrophic nerve-fibres, and all the evidences of an essentially chronic non-suppurative inflammation.

For these reasons, and from a consideration of the results of other experiments and clinical observations, the bacterial nature of sympathetic ophthalmitis has been accepted by many ophthalmologists of authority. Schweigger, Leber, Snellen, Mooren, Alt, Mules, and others have put themselves unreservedly on record as believing this to be the best explanation of the intricate subject of sympathetic ophthalmitis.

To the writer, however, the view has not presented itself so convincingly; the progress of bacterial infection elsewhere in the human subject is so much more rapid than in sympathetic ophthalmitis, and the course here is so different from that of other well-authenticated septic

(bacterial) infections of the eye, as in metastatic choroiditis and retinitis, that it seems to be going too far, for the sake of a theory, to regard the processes as essentially the same. The advocates of this view apparently ignore also some very important clinical facts that should be regarded as characteristic of the disease. In order to establish their theory, they insist upon an essential difference between sympathetic irritation and sympathetic inflammation, asserting that the former never passes into the latter, and that if it remains in the irritative stage there is no propriety in calling it sympathetic inflammation. As has already been stated, among the clinical facts which first direct the attention of the patient to his eye, and for which he first consults the surgeon, is a certain, perhaps trifling, photophobia, lachrymation, and pain on use; as the patient usually expresses it, his eye gets tired easily, and if the disease be unrelieved after a variable time, and perhaps after repeated attacks alternating with apparent recoveries, a pronounced inflammation sets in. These facts are undisputed, and the claim that the irritation is but a premonitory stage to the inflammation is certainly not a forced one.

The uncertainty of the time of the appearance of the inflammation in both the injured and the sympathizing eyes, varying, as it may, from a few weeks to even forty years after the receipt of the injury, argues against the microbial theory. And the fact that in one set of cases there may be repeated attacks of irritation, while in another set the original wound may heal, and the eye may remain in a quiescent condition for years, the inflammation starting up then, with no new wound (or it may even be that the injured eye takes on no fresh action, but the fellow-eye becomes inflamed and goes through the stages of iritis, irido-cyclitis, or neuro-retinitis, to the loss of a greater or less degree of sight), is inexplicable by any theory of constant bacterial infection, but is quite reconcilable to the nervous view. If the bacteria were introduced at the time of the injury, what has prevented their development during the years of quiescence of the eye? If present at all, they were always in the same culture medium, and wherefore then this long delay, and what is the cause of their sudden activity? There can be no change in the culture medium but that which has already taken place many times before during the long period of inactivity.

These well-established clinical facts do not harmonize with the bacteriological theory, while there is nothing to disprove the opinion, gradually developed through years of observation of the clinical phenomena, that the sympathetic inflammation is brought about by a neuritis of the ciliary nerves of both eyes, caused in the first eye by the entanglement of the terminal fibres in the cicatrix of the wound, propagated thence to the fellow-eye. This propagation may be by way of the ciliary nerves, and through the medium of the ophthalmic ganglia of the sympathetic nervous system and the vaso-motor nerves, to the ciliary nerves of the fellow-eye, there exciting trophic disturbance in the tissues to which the nerves are distributed, and giving rise to the various inflammations of the anterior segment of the globe above described; or the irritation may be transmitted more directly by the optic nerves to the posterior segment, giving rise to the neuro-retinitis described. The former is the common mode, the latter the exceptional.

The writer is aware of the indefiniteness in the description of the extension of the inflammation through the medium of the sympathetic system; so also is our knowledge of the physiology of this system indefinite, but it is doing no violence to our knowledge of the action of this complex system to assume this much.

There is also a certain analogy (not identity) between this sympathetic process and those trophic changes observed in distant parts following severe injuries to the main nerve-trunk. The observations of Mitchell, Morehouse, and Keen have shown that there may be very general changes of the tissues to which the nerve is distributed, evident especially in the skin and its adnexa, and the joints, although the muscular, osseous, and cellular tissues may all occasionally show grave changes. In the joints (arthropathies) the evidence of an inflammatory process is shown in a painful swelling, a slight redness about the articulation, extreme sensibility, and finally, persistent rigidity and a semi-anchylosis which resists all treatment. When the acute stage has disappeared the tissues around the articulation are indurated, and there results a partial anchylosis. In the skin there is a peculiar, glossy redness or erythema, there may be eruptions of different kinds, the glands disappear, etc. Mitchell has shown that these trophic disturbances follow incomplete sections, contusions, punctures of a nerve—in other words, causes which determine an irritation of a nerve rather than its complete local destruction. It seems to me that we are justified in believing that the conditions which pertain in sympathetic ophthalmitis bear a sufficiently strong resemblance to those of nerve-irritation, and consequent trophic changes, to justify us in accepting this in preference to the bacteriological theory.

The intractable nature of this disease, and its obstinacy in resisting treatment have already more than once been referred to. Mackenzie was led to seek for a reason for the fact that a certain number of cases of ophthalmitis, beginning apparently in a mild way, were so excessively obstinate in their resistance to modes of treatment which were fairly successful in other cases. He noticed that they were all associated with an injury to the other eye, and he then grouped them into the class we are considering. The futility of all the ordinary methods of treatment for sympathetic iritis and its complications, as well as for neuro-retinitis of sympathetic origin, was early recognized. Although the observation of a greater number of cases has shown that *all* do not run an absolutely unfavorable course, still instances of this kind are exceptional, and we should regard every case that presents itself as threatening total blindness of that eye, even though a considerable degree of vision may remain in the injured eye.

In 1857 Dr. August Pritchard, of Bristol, England, recognized the importance of relieving the sympathizing eye of the source of the irritation by removing the injured eye entirely, when vision in it was totally lost. This operation (enucleation, Arlt), was followed by a relief of the inflammation in the fellow-eye, and has ever since been acknowledged to be the most promising means of combating this so fatal disease. Although a wider experience has shown its limitations, it or its modifications may still be regarded somewhat as a specific for this unique form of inflammatory action.

The uncontrollable tendency in the plastic material thrown out in the inflammation of the uveal tract, to contract after the active stage has passed, the contraction being as certain as that following deep burns of the skin, shows the importance of getting early control of the disease before the plastic lymph has been effused. And the results of the operation show that, to be of much benefit, the enucleation must be performed either as a prophylactic measure, before any evidences of irritation or inflammation have shown themselves, or during the irritative stage, before organic changes have taken place. If performed after inflammation has fairly begun, while it may possibly mitigate the severity of the process, it seldom saves good vision; the secondary (cicatricial) contraction usually produces such a fusion of iris, lens, capsule, and ciliary body that no subsequent operative interference is of avail. It is still doubtful, if the enucleation be delayed, whether it mitigates the ophthalmitis at all; occasionally it seems but to add to the severity of the symptoms, the subsequent course being even more rapid than before.

The importance of an early operation, if it is to be done at all, is, therefore, very great, and the question of probability of sympathetic ophthalmitis occurring at all is of the utmost importance; for while there can be no doubt as to the advice to offer when the question is distinctly between total blindness and mutilation, when it is simply between mutilation and a more or less remote chance of blindness patients will always hesitate and often decline the operation. Statistics are wanting as to the exact proportions between all injuries and sympathetic

ophthalmitis; but, as has been stated, injuries of the ciliary region, causing the entanglement of the iris, ciliary muscle and processes, and choroid, "especially if there be loss of vitreous" (Mackenzie), and foreign bodies remaining in the globe, whether the penetration be through the ciliary region or not, are all such constant sources of danger that *if the vision be destroyed* the surgeon should take the responsibility of advising the removal of the eye. The sooner this is done in such cases the better, usually, though in childhood the enucleation is liable to check the normal development of the orbital cavity and produce a greater deformity than if it be practised after the bones of the face have attained nearly their full development.

Whether the globe should or should not be removed during active suppuration has been discussed in the article Panophthalmitis, but the necessity is not so great on account of the sympathetic dangers as of relieving present suffering. Leaving for a moment the question of the effect of this operation on the preservation of vision in the fellow-eye, it must be remembered that there is still a positive, though fortunately but very slight, danger to life in the operation for removal, even without a panophthalmitis; deaths have followed from meningitis or from shock in several reported instances, and in how many unreported cases no one knows.

If there still be vision, or a remote prospect of saving some, the wound being in a dangerous situation, the problem becomes more difficult of solution, for, if the patient wait for symptoms in the fellow-eye, he may delay too long, or the irritative stage may be so rapidly followed by the inflammatory process that the operation is useless; and yet neither surgeon nor patient wishes to sacrifice an eye there is a prospect of seeing with. Furthermore, there have been unfortunate cases in which the enucleation itself has seemed to precipitate, if not cause, the outbreak of the sympathetic disease.

Recognizing, as we must, the double path of the disease from one eye to the other, it is evident that if the disease be of the neuro-retinal form, and have advanced along the optic nerve to a distance beyond the point of division, the operation is likely to be an additional irritation to the already inflamed tissue, and may readily be sufficient to cause the loss of the fellow-eye; and if there be a bacterial influence at work there will be a better chance for the introduction of the germs.

Undoubtedly many eyes with some useful vision in them have been sacrificed to the fear that the fellow-eye may become affected; but the converse is also true, and many more eyes have been lost and total blindness has resulted by reason of the repugnance to submit to enucleation. The surgeon is at fault in the former case, the patient usually in the latter.

If the patient can be depended upon, as most persons of intelligence may, the operation may be postponed, with the express understanding, however, that he will report immediately upon the appearance of the *first* symptom of irritation, such as lachrymation or other difficulty in the use of eyes for near work, photophobia, or phosphenes (photopsia), when the surgeon must determine whether there is any danger of an increase of the process, or may detect by the ophthalmoscope the presence of optic neuritis (papillitis) or choroidal trouble. In the presence of any positive evidences of disease, however slight, the operation must be advised. If the injured eye is the seat of chronic inflammation, with periods of exacerbation, it should be removed; or, if the patient first presents himself with the history of repeated slight attacks of irritation in the fellow-eye, the removal of the injured eye should be advised.

The history of the enucleation in those infrequent cases of serous iritis or of glaucomatous processes, does not warrant so favorable an opinion of its utility. Why this should be the case it is difficult to say, but the observations seem to be fairly uniform and may be regarded as an argument against the existence of a sympathetic glaucoma. Mauthner has formulated his opinions on the advisability of enucleation as follows: It *may* be performed as a prophylactic measure; it *must* be done in the irritative stage; it *must not* be performed in active iritis, serous or plastic; it *can* be done in irido-cyclitis (the sympathizing eye being quite blind and not in a condition of active irritation).* While rules thus positively stated are legitimate subjects of criticism, they may be regarded as representing in the main the general views of ophthalmologists of the day.

In view of the natural repugnance of the patient to being subjected to so severe a mutilation, and of the surgeon to being compelled to inflict it, ophthalmologists have sought to devise some means to accomplish the separation of the injured eye from its fellow, in which this objection would not apply. Regarding the nerves, optic and ciliary, as being the media of transmission of the morbid influence, von Graefe advised and practised the division of these nerves behind the injured eye, and for several years afterward the bibliography of ophthalmology was plentifully strewn with reports of optico-ciliary neurotomy and its effects, and although the authors continued to report successful cases, that is to say, cases in which disease did not develop in the fellow-eye (prophylaxis), or in which the eye was benefited, the practical demonstration of the benefit of the operation, its general adoption by the profession, is yet wanting. The uncertainty of being able to make successfully the division of the ciliary nerves has always stood in the way of the surgeon's ability to guarantee to the patient a relief from the threatening blindness with as much confidence as he could were enucleation to be performed. The operation has never received an equal degree of sanction by the profession as has enucleation, and has gradually fallen into comparative disuse. It is, however, to be proposed as a tentative procedure in cases where the repugnance to removal of the globe cannot be overcome, but if the symptoms return or persist, the enucleation must be performed later.

The neurotomy may be performed with or without division of the rectus muscle; there is not much choice between the external and internal. If performed without division of the muscle, a longitudinal incision, parallel to and just above the upper border of the external rectus muscle, is to be made through the conjunctiva, a pair of long-bladed scissors, curved on the flat, are introduced, and then all the short ciliary nerves external to the optic nerve are freely divided. A strabismus hook is next introduced, and the optic nerve is seized and drawn as far out of the wound as possible, thus rotating the globe on its vertical axis and turning the cornea inward. This allows the nerve to be cut off far back in the orbit, when the portion attached to the globe may be seized with the forceps, the globe reversed further yet, and the piece of the nerve still attached removed close to its entrance in the globe. The ciliary nerves internal to the optic nerve are now accessible and must be entirely removed.

The division of the muscle allows freer access to the posterior part of the globe and secures a much more certain division and resection of the nerves, both optic and ciliary, and the operation is thus more readily carried out, but a considerable strabismus is apt to remain. To avoid this it is well before dividing the muscle to pass a thread through it and after the neurotomy has been performed to stitch it again to its place.

Either of these operations, and especially the latter, has the very serious objection of being liable to be followed by considerable hæmorrhage, which, by filling the orbit, pushes the eyeball forward (exophthalmos) and is sometimes followed by such severe and uncontrollable pain as to require the enucleation after all,—a condition of things which can but tend to aggravate the disease sought to be relieved.

Is there any other treatment than getting rid of the source of the irritation which is of avail? Can anything be done to check the progress of the disease in the sympathizing eye itself? But little; though no surgeon could feel himself justified in making no attempt to save an eye thus affected, however hopeless he may think it.

* The exact meaning of the last sentence, "it *can*," etc., is not altogether clear unless it be that the injured eye is to be removed to relieve intolerable pain, even if the sympathizing eye be blind; otherwise the word sympathizing is a misprint for injured.

In iritis and irido-cyclitis the instillation of atropine must be persistently carried out. By its paralyzing action on the iris and ciliary muscle, it keeps them at rest, thus alleviating pain and tending to reduce inflammatory action, and it may happen that the iritis will subside while the pupil is dilated and before it becomes blocked up with lymph. Leeches may be applied to the temple, or if these be unobtainable Heurteloup's or some other form of artificial leech, with cupping, may be substituted. With the idea that mercury checks adhesive inflammation some form of this drug may be administered to the production of gentle salivation. These are the routine remedies in general use, and their good effects are not to be ignored or underestimated, but neither is the surgeon justified in building much hope upon them in either his own or his patient's mind. I have seen an iris which was fully dilated with atropine in the early stages of sympathetic ophthalmitis, the patient being kept on the verge of poisoning with it, gradually contract day by day; lymph continue to be poured into the pupil, the latter become hopelessly blocked up, the iris bulge forward, and total blindness ensue, in spite of the atropine, mercury, and leeches. In other cases, milder usually from the start, this treatment occasionally seems to be followed by such amelioration of the symptoms that the surgeon cannot but hope that the next case will prove equally responsive to his treatment. These are, however, the exceptions.

The results of operative interference in the acute stage are usually disastrous. An iridectomy is almost surely followed by an increase of the iritis. It is not until the eye has been entirely free from inflammation for several months, and when there is also good reason to believe that there is no detachment of the retina or other lesion of the fundus—that is, that the acute inflammation was confined to the iris and the changes which followed were merely incident to this,—that, in cataract with closed pupil and a blocking up of the posterior chamber, a broad iridectomy, with simultaneous or successive extraction of the cataract, may be made. In all probability successive lacerations and removals of false pupillary membranes and membranous deposits behind the iris, with repeated iridectomies, will be required. If it be necessary to repeat any operative procedure, or if successive operations be required, time must be given between them to let all inflammation subside. These operations are described in other parts of this work under the proper heads of Cataract and Iridectomy, so that it is unnecessary to repeat their description here.

Addendum.—Through the very great courtesy of Professor William H. Welch, of Johns Hopkins University, and Dr. R. L. Randolph, of Baltimore, Md., I am enabled to give here, in advance of publication elsewhere, the results of a series of attempts to verify Deutschmann's experiments on the production of sympathetic ophthalmitis in the lower animals.

"The experiments were performed upon dogs. Four or five drops of a solution of staphylococcus pyogenes aureus were injected into the corpus vitreum, using for this purpose a hypodermic syringe which had been previously thoroughly sterilized, taking especial care that none of the solution came in contact with the edges of the puncture, thus avoiding, as far as possible, the inoculation of the surrounding tissues, and setting up a general inflammation. Clouding of the vitreous was observed in every instance an hour after the operation. In twenty-four hours the fundus was no longer to be seen. In every case but three, panophthalmitis ensued, followed by rupture of the eyeball and disorganization of its contents. In the three cases mentioned the eye recovered after a severe kerato-iritis, which left the cornea clouded and deposits upon the anterior capsule (of the lens). The pupils, however, responded to light, showing that the optic nerve-fibres possessed functional activity. It was impossible to see whether the fundus had participated in the inflammation. Examination of the uninjured eye with the ophthalmoscope revealed in every instance a perfectly normal fundus; not even did the blood-vessels of the retina show anything that would suggest that they sympathized with the condition existing in the inoculated eye.

"The dogs were all killed at periods varing from twenty days to three months. On examining sections of the inoculated eyes, dense, round-celled infiltration was seen throughout the coats, in which the papilla participated. In several the inflammation extended to within half an inch of the chiasm. In only one case did the neuritis reach the chiasm, and then it was confined and stopped on that side of the chiasm adjacent to, and continuous with, the optic nerve of the inoculated eye. *The presence of organisms in the tissues of the eye, or optic nerve, of the side not inoculated was never detected.*

"This is the first time that dogs have been used for experiments of this nature. It is possible that they possess an immunity from sympathetic ophthalmia, or that we are not apt to have the disease when the eyeball ruptures, though the case in which the inflammation was seen in the chiasm happened in a dog whose eye had ruptured forty-eight hours after inoculation. In this case, however, the inflammation must have spread from continuity and exhausted itself by the time it reached the chiasm. Certainly if the cocci had been the *causæ morbi*, there is no reason to think that they would have lost vitality after reaching the chiasm. The same reasoning would apply to the other cases where the inflammation had travelled some distance up the optic nerve."

Comment on these experiments is superfluous on my part. I allow myself, however, to say this much: I was entirely unaware that they were in progress until after the above article was finished, and I then learned of them through my friend Dr. Theobald. I am, of course, pleased to be able to confirm the views I have expressed, which were derived from a study of the clinical phenomena, by the negative results of experiments carried on by such competent authorities.

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SYMPHYSIOTOMY. Delivery of the fœtus by pubic section, in cases of pelvic deformity, was devised in 1768, by Jean René Sigault, a French medical student, who sent the proposition to the Academy of Surgery of Paris, by the members of which it was regarded as the wild scheme of an ignorant youth. Not regarding this stamp of disapproval, he made it the subject of his thesis at Angers, in 1773. In so far as his method was designed to apply to the living woman in parturition, it was original with Sigault, but it had twice been tried upon the dead woman. The first operation upon a woman who had died in labor was performed at Warsaw, in 1655, by Dr. Jean V. C. Delacourvée, of France, then in practice there, the subject, aged forty-eight, having been in labor four days; and the second was in 1766, under Professor Jos. Jacques Plenck, of Bude, Hungary, for the liberation of a locked head in a post-mortem Cæsarean section. It does not appear that it ever entered into the thoughts of either of these obstetricians that such an operation might be of value in the cases of living women.

After his graduation Dr. Sigault embraced an early opportunity of carrying his scheme into effect, and on October 1, 1777, performed the initial operation, upon Madame Souchot, a dwarf of three feet eight inches in height, and delivered her of a living child, having a bi-parietal diameter of three inches and one line. The pelvis measured in its true conjugate, two inches and three-quarters (Eng.), and the child presenting by the feet was readily extracted. This was the fifth pregnancy of the mother, and her first child delivered alive. A permanent disability resulted from the use of the knife, in the form of an incontinence of urine.

The result of this case, although in a measure imperfect, and not a fair test of the value of the operation, because of the working space, three inches, in the superior strait, gave great credit to the operator, much to the annoyance of the Academy of Surgery, by which it had been condemned nine years before. Not content with a moderate degree of praise upon the test of one operation, Dr. Sigault was lauded as a public benefactor; a medal was presented to him by the Faculty of Medicine, and the government granted to the operator and the patient —the latter the wife of a soldier—each a pension. This excess of adulation created a feeling for and against the operation, in which the Academy of Surgery took an active part; and as it was claimed that the pubic section was to take the place of the Cæsarean operation, the medical profession became divided into *Symphysiotomists* and *Cæsareanists*, each advocating the one plan of delivery to the disparaging of the other. The basis of the scheme of Sigault was the claim that relaxation of the pelvic synchondroses took place during the latter months of pregnancy, and it was only requisite to open the pubic symphysis by the knife, after which the sacro-iliac junctions might be made to move like a hinge, and admit of a wide separation at the point of section, without strain or injury of the posterior synchondroses. This measure of relaxation was denied by many, upon the results obtained by experiments anything but crucial, made upon dead bodies, under which the ligaments tore. Years later, when the excitement was over, and the operation rarely performed, experiments properly conducted, and without prejudice, under Dr. Girard, of Paris, in 1800, and Dr. Ainsiaux, of Liége, in 1811, elicited very different results. The bodies of women who died in labor were used as subjects of the test, and it was found that when operated upon soon after death the mobility of the pelvic bones upon each other was quite marked, and would admit of a wide separation at the pubes without laceration. Dr. Ainsiaux obtained, under these circumstances, as much as three inches; but found that when a woman had been dead thirty-six, thirty-eight, forty-eight, or fifty-four hours, he could only separate the bones one and one-half to one and one-fourth inch without laceration.

The original Sigaultian operation was very simple in its method of execution, but was liable to accidents, from the knife incising too deeply behind the symphysis, or through the pubic arch, or not taking the central line of junction between the pubic bones, but cutting a piece from one of them, leading to a delayed union, with perhaps escape of a fragment of bone.

In the year 1778 the operation was fairly inaugurated, as it was performed eleven times, under eight operators,

in Germany, France, Belgium, and Bavaria, four of the sections having been the work of Sigault himself, who ended his experience, after having had five cases, with four women and one child saved. Under the whole eleven operations of the year, six women were saved, and ten children were lost. This was certainly not very encouraging for an operation designed to save two lives and to supersede the Cæsarean section, if not entirely, at least in large measure. Too much was expected of the operation, and attempts were made in cases where the pelvic contraction was entirely too great for success. Sigault failed, on this account, with his fifth and last operation, which was upon a dwarf of thirty inches high, pregnant with a fœtus twenty inches long, and having a conjugate herself, computed at twenty-two or twenty-three lines. She died of pelvic injuries in five days. This failure appears to have put a check upon his ambition, and he subsequently declined to test his method upon a woman having a two and one-half inch conjugate. Pelvic injuries and fœtal death appear to us now to have largely resulted from the method of delivery usually adopted—the child being turned and its head drawn through the superior strait, thus forcing open the sacro-iliac symphyses, and destroying the fœtus at the same time.

In the second year of the operation (1779) there was a falling off in numbers to four, saving all of the women and two children, the cases being all in France, and two of them under the care of Dr. Alphonse Leroy, who became an early advocate of the operation, and performed it during a period of twenty-six years, his last delivery under it being in 1804. Leroy operated in this period only five times, but is twice recorded as having assisted others. Four of his own patients recovered, and three children were saved; two others were delivered in a moribund state, both by the feet.

In 1780 there were but two operations as far as recorded, and the same in 1781; after which they varied in numbers from one to four each year until 1840, between which and 1858 (when they ceased, with two fatal exceptions in Bologna, in 1863 and 1865, until the revival of the method in a much less fatal form in Naples, in the year 1866) there were but six cases.

From 1777 to 1866, the year of the revival referred to, there were 86 operations, of which the results have been recorded; a few others have been mentioned, but no particulars given. Of the 86 women, 57 recovered, and 29 died; 45 of their children were delivered dead; 6 in a dying condition; the fate of 6 is not mentioned, and 29 were saved. It is evident that the operation gradually fell into disuse, largely on account of its failure to save the lives of the children.

The subcutaneous method of incision was introduced at Utrera, Andalusia, Spain, on August 9, 1780, by Professor Francisco Canivel, of the University of Cadiz, who directed an operation performed by a licentiate, Amonio Delando. The case was that of a primipara, aged forty-two, in labor three days, and was the eighteenth operation in chronological order. As is done in Naples with so much success at the present day, the incision was made from below upward, and from within outward. The woman recovered in thirty-eight days, and the child was saved. Cazeau, very erroneously, credits the initiation of this method to Dr. Imbert, of Lyons, who recommended it in 1833, fifty-three years after its first successful performance.

Symphysiotomy was first performed in Italy by Dr. Antonio Lavaguigno, of Genoa, on December 24, 1781, upon a subject having a conjugate of 65 mm. or $2\frac{9}{16}$ inches. The fœtus presented by the head, and being thought dead, was extracted with a crotchet, and lived several hours. The woman died in seventeen days, her external and internal parts being gangrenous. This destructive condition of the soft parts appears to have been a not unusual sequel of the operation of Sigault in its early days, particularly in cases of extreme pelvic deformity, where tractile force, rather than nature's process of extrusion, was relied upon for the delivery of the fœtus. Symphysiotomy was first performed in Naples, in 1787, by Professor Domenico Ferrara, upon Vittoria di Montesarchio, who recovered, but in whom the symphyses failed to unite. She was living and able to walk twenty years later, being employed as a messenger; her child was lost.

Between the operation of Ferrara and that of Jacolucci, on July 25, 1858, when the old period may be said to have closed upon symphysiotomy in the city of Naples, there were performed in that city, including the two named cases, twenty-seven operations, of which sixteen were under Professor Genaro Galbiati, who was the inventor of the strong curved button-ended bistoury (falcetta) in use at the present day in making the subpubic section. Galbiati's operations were largely upon pelves having a $2\frac{9}{16}$ inch conjugate, and hence a very severe test of the method. Eight were of this measure; two were of $2\frac{1}{2}$ inches; three were of $2\frac{3}{8}$; three were malacosteon deformity; and in one, the conjugate was reduced to 51 mm., or only 2 inches; this last died undelivered. Eight of the women were saved, and but four of the children. The whole twenty-seven Neapolitan operations saved sixteen women and ten children.

Failing to obtain from the operation of Sigault the advantages of the Cæsarean section in cases of extreme pelvic stenosis, Professor Galbiati devised and executed, in 1832, the murderous operation known as *bipubiotomy*. Having a pregnant dwarf under his care, $3\frac{1}{2}$ feet high, with a conjugate of only an inch, he conceived the plan of opening her pelvis like a bellows, by disconnecting its anterior from its posterior portion, by a subcutaneous section made with a chain-saw through the horizontal and descending rami of the ossa pubes on either side. This scheme he put into execution on March 30th of that year, and delivered the woman of a dead fœtus, but such was the injury inflicted on the mother that she died in agony four days later, her vulva, vagina, and surrounding tissues being all gangrenous. Not contented with this test, Dr. Nanziante Ippolito repeated the experiment in the *Ospedale dei Incurabili*, ten years later, with a similar fatality; and recently we have noticed a proposal in Europe, by some one who must be ignorant of what has been already done, to make trial of this murderous and unscientific measure.

Since the year 1818 symphysiotomy has had its home exclusively in Italy, and but very few operations have taken place outside of the city of Naples, in whose Hospital for Incurables the work has been chiefly done. In 1858 it entirely died out even there, and for a period of eight years there was not an operation. Rachitic deformity being quite prevalent, and there having been lost over ninety-two per cent. of all of their Cæsarean cases in seventy-five years, although all of the children were delivered alive, the medical staff of the hospital felt called upon to do something to lessen this fearful mortality, and, strange as it may appear, her obstetricians chose to revive the much-abused and destructive operation, especially to children, of Jean René Sigault; and the work recommenced on January 5, 1866. By the use of the subcutaneous method of incision, and the avoidance of version, or any unnecessary tractile force, it was soon found that the fœtal head would slowly expand the superior strait, become moulded to its form under the contractions of the uterus, aided by the expulsive efforts of the mother, and finally extruded without material injury to the sacro-iliac synchondroses, or causing the death of the fœtus, except in small proportion. Since the above-named date the operation has been performed in Naples 76 times, with a saving of 57 women, or seventy-five per cent., and 58 children, or $76\frac{7}{38}$ per cent. In these are included two operations where labor was induced in the seventh and eighth months respectively, saving both women and one child; and one in which the fœtus being dead, and the conjugate under two inches, the superior strait was enlarged by separating the symphysis, and the fœtus was then delivered under craniotomy. The woman recovered in forty-two days. Professor Novi, who performed this operation, on September 8, 1872, doubted the propriety of risking the Cæsarean section for the removal of a dead fœtus, which being of full size could only be removed

by craniotomy alone, at great risk, through so narrow a pelvis. He has had three craniotomy cases since.

The association of symphysiotomy with the induction of premature labor, in the cases of rachitic dwarfs having very small pelves, is well illustrated in the following record, and by photographs sent to me from Naples. Probably the operator at the present day would weigh the question of performing the Sänger operation at term. Lucia Esposito, a rachitic dwarf, aged twenty, and 3 feet 7¾ inches high, having a true conjugate of $2\frac{3}{16}$ inches, entered the obstetric clinic of Naples on May 15, 1880, in the seventh month of her pregnancy. When the extent of her deformity was ascertained it was determined by Professor Ottavio Morisani to bring on her labor in the first week of the eighth month, and this was accordingly done on June 9th. On June 11th, labor being sufficiently advanced, the symphysis was opened, and the fœtal head, which presented by the vertex, began to descend, passed into the pelvic cavity, met with some delay at the perineum, and was finally extruded. The fœtus began soon to breathe regularly; it weighed 4¼ pounds; measured 15¾ inches in length; occipito-mental diameter, 4⅜ inches; biparietal, 3 inches; occipito-frontal, 3½ inches; and bitemporal, 2⅝ inches. The child, when three days old, was sent to a foundling hospital. Being in summer, the wound was treated by irrigation, and at the end of a week by an immovable apparatus for fixing the pelvis, an opening being left over the wound. Union was complete in thirty-four days, and the patient left her bed in forty, being soon able to walk without pain or inconvenience.

In the early days of Sigault's operation the main contention was upon the measure that might be gained in the sacro-pubic diameter by each inch of separation of the ossa pubis, and the amount of injury to the sacro-iliac synchondroses that must be inflicted by the forcible separation of the innominata. Since the revival of the operation the value of slow separation and head-moulding have been considered, and the gain in the transverse and oblique diameters found of great importance to the passage of the head. Careful and accurate pelvic measurements must be made, and the operation should not be undertaken where the conjugata vera is less than 67 mm., or 2⅝ inches. The operation is best adapted to the symmetrical rachitic pelvis. If there is any asymmetry, extra care must be taken in finding the anatomical centre of the symphysis, so as to avoid slicing off the end of one os pubis, as has several times happened, in which event the exsected piece will become carious and a fistula will remain until it is discharged or removed. The operation is not admissible where disease has affected one or both of the sacro-iliac symphyses, as in the oblique pelvis of Naegelé, or the still narrower and anchylosed one of Robert. In the flat-sided pelvis produced by coxalgic anchylosis of one hip-joint, where one ilium is undeveloped, there is apt to be a bony union between the sacrum and ilium, making pubic section unavailable.

The amount of separation usually obtained in the operations at Naples, 50 mm. (2 inches) it is claimed, may be secured without risk of injury to the sacro-iliac symphyses. Version should not be resorted to when the head can be made to engage. The forceps have been applied in about one case out of four. Under the first fifty operations in the *Ospedale dei Incurabili* of Naples (1866–1880) vesico-vaginal fistula was produced in but one case, which was easily cured by an operation. Firm union of the symphysis pubis was secured in the cases of the 40 women who were saved out of the first 50 operated on, and Professor Morisani has assured me that these women had good health after the operation. Of the 50 fœtuses delivered, 46 presented by the vertex, and 42 of these were alive on removal.

CAUSES OF DEATH.—In 19 Neapolitan subjects the causes of death are thus recorded: Metro-peritonitis, 3; septic metro-peritonitis, 1 (endemic in hospital); iliac phlegmon and metro-peritonitis, 1; peritonitis, 2; endocarditis, twenty-four days after operation, 1; endocarditis and diphtheritic vaginitis, 1; puerperal infection, parametritis, pelvic abscess, and tetanus, 1; gangrenous endometritis, 1; long labor and repeated application of forceps prior to section, 1; long labor and pelvic tumor, 1; labor three days, fœtus dead, *operation unjustifiable*, 1; *operation unjustifiable*, fœtus dead, c. v. $3\frac{3}{16}$ inches, 1; *the same*, labor induced, fœtus dead, c. v. 74 mm. (nearly 3 inches), 1; not stated, 2.

The history of symphysiotomy not only embraces two entirely distinct periods, but its prognosis is signally changed as regards the mother, and much more decidedly so in reference to the fœtus in utero; in fact, an entire revolution has been produced in the second period, as compared with the first. This is shown not only in the diminution of the death-rate, but in the causes which lead to death. I have given those since 1866, and will now mention some taken from the records of the eighteenth century, viz., external and internal gangrene, pelvic injuries, gangrene of the genitalia, intrapelvic parts found gangrenous, etc. Fœtal death has largely diminished since version and traction by the feet have become the exceptions in practice. Now the fœtal mortality is twenty-four per cent., and was but 18 out of the first 50, commencing in 1866. In the old period about five fœtuses out of eight were either dead or moribund when extracted.

DISTRIBUTION OF CASES.—Symphysiotomy has never been performed in the United States, and only once in Great Britain. In Italy there have been 115 operations; in France, 32; Holland, 6; Belgium, 4; Germany, 3; Spain, 1; England, 1; total, 162; it is said also to have been performed in Constantinople—no results have as yet been found reported.

Symphysiotomy can never take the place of gastrohysterotomy in cases of extreme pelvic stenosis, as by general consent among operators the minimum available conjugate has been fixed at 67 mm., or 2⅝ inches. Of 68 cases reported by Professor Ottavio Morisani, Director of the Obstetric Clinic of Naples, only 2 were under this measure; 18 gave the 67 mm., and the balance ranged from 68 to 81 mm., there being 20 at the last computation ($3\frac{3}{16}$ inches). There were five deaths at each measurement, *i.e.*, 67 and 81, and eight at the intermediate points.

Thus it will be seen that the operation of Sigault has a conjugate range of a fraction over half an inch, and covers the ground within which craniotomy can be most safely performed. Executed with the care and skill of a Morisani, the operation he has revived in preference to it (*i.e.*, craniotomy), has no greater fatality, and possesses the material advantage of saving the fœtus. In these days, when the opposition to craniotomy increases as the risks of the Cæsarean section diminish, there is a growing inclination on the part of gynecologists to adopt the use of the knife, in some one of the several forms in which it may be employed, for the saving of mother and child. The Sänger operation is now the most highly extolled for its moderate death-rate, and fœtal-saving under it is almost universal. But there is an objection of long standing against the Cæsarean section, where the sacro-pubic diameter measures from two and three-fourths to three and one-fourth inches. A well developed fœtus will become head-locked in a three-inch pelvis, and will die if not liberated; craniotomy may accomplish this, with very little risk to the woman, but the child will be lost. Fœtus after fœtus has been thus disposed of, for one and the same woman, until a numerous progeny has been destroyed that she might escape death. Should there not be an end to infantile destruction in such cases, and does not symphysiotomy afford a means whereby the fœtus may be saved, without very great danger to the mother?

The induction of premature labor, as in the hands of the late Dr. Cæsare Belleozzi, of Bologna, who operated more than one hundred and twelve times, may accomplish this end; but what is to be done where the patient is not examined until near her maturity of gestation, or in actual labor? There is this to be claimed in favor of symphysiotomy, or the Sänger Cæsarean operation at full term, that a very small proportion of infants delivered prematurely, live through the first year, because of their immaturity of development. *Robert P. Harris.*

SYNCOPE, or fainting, is a condition of sudden unconsciousness of short duration, ending with complete recovery. It can be produced by unpleasant mental impressions, such as fear, dread, and shocking news, or the sight of suffering of others. Some persons faint from the sight of blood or the expectation of any trivial operation. Acute personal suffering may also lead to syncope, perhaps more through mental influences than by direct reflex action. Operations on the ear and the male genital organs are especially apt to cause fainting. Oppressive heat may also induce fainting. While syncope may occur in perfect health, though rarely, it is much more likely to take place in conditions of enfeebled health. Nervousness, in the sense of imperfect control of the inhibitory nervous system, anæmia, convalescence from debilitating diseases, and almost all forms of heart disease, render the individual prone to fainting on slight provocations.

Prior to the loss of consciousness the subject feels weak and faint, sometimes dizzy, becomes pale in the face, which is usually covered with cold sweat; the sight fails, everything becomes dark, there is often a roaring noise in the ears, until at last the control over the muscles is lost and the subject falls down unconscious and limp.

The unconsciousness lasts rarely longer than a few minutes. On recovery a feeling of faintness may persist for a short time. In enfeebled health several fainting fits may follow in succession. On the other hand, the tendency to syncope may be checked before unconsciousness occurs by removing the cause—for instance, avoiding the sight of some awe-inspiring scene.

On account of the rapid and perfect recovery, a fainting fit could hardly be mistaken for an apoplectic seizure. From major epilepsy it differs by the want of spasms. But from an attack of minor epilepsy (petit mal) fainting cannot be distinguished, except by taking into account the preceding causes, if any, and the history.

In the light of modern physiological knowledge the essential condition of syncope must be regarded as anæmia of the brain, presumably the cerebral cortex—the seat of consciousness. For unconsciousness can be experimentally produced in animals by inducing cerebral anæmia, as by hæmorrhage or ligature of the carotid and vertebral arteries, and it occurs also in man under similar conditions. The pallor of the face during fainting renders it likely that the blood-vessels inside of the cranium are also constricted. Moreover, any measures which increase the blood-supply to the brain, like the recumbent position or the inhalation of nitrite of amyl, may check the fainting tendency before consciousness is lost. The cerebral anæmia produced in animals by hæmorrhage or ligature of the arteries of the head leads to convulsions, while in ordinary fainting no muscular spasms occur. Whether the anæmia during syncope is not as intense as during the experimental state, or whether the constriction of the blood-vessels does not involve the region of the basal ganglia in syncope, is not settled. The pulse is usually slow during fainting, and sometimes long pauses exist between separate pulsations—evidently action of the vagus. This inhibition of the heart through vagus action occurs similarly in experimental cerebral anæmia from excitation of the vagus centre. Whether a primary excitation of the vagus can lead to fainting is not known. In most instances fainting must be regarded as an influence of emotions upon the centres of the vaso-constrictor nerves of the cerebral hemispheres.

In order to prevent the loss of consciousness from a threatening attack of fainting the cause should be avoided as far as possible. It is well to loosen any tight apparel, especially the corsets of women, since constriction of the waist increases the liability to syncope. The cerebral anæmia should be counteracted by placing the patient on his back, with the head low. Unnecessary meddling is not called for. Amyl nitrite may be of service if on hand. These measures may also shorten the period of unconsciousness. For this purpose any mode of stimulation of the skin, like a fresh draught or sprinkling with cold water, may also be employed. The liability to fainting can be combated only by those means which restore a more or less perfect health according to the general condition of the patient.

H. Gradle.

SYNOVITIS, ACUTE. Synonyms: Hydrops articulorum acutus, acute serous synovitis, arthro-meningitis, sero-synovitis; French, Synovite aiguë; German, Die Synovitis.

Synovial membranes approach so closely to the serous membranes that they are often classified with them.

Anatomy.

But, although structurally much the same, they differ from the serous membranes in secreting a peculiar fluid, synovia, and they are not, like the peritoneum, etc., closed sacs. In all joints where motion takes place (diarthrodia) a lubricating fluid is necessary, and this fluid is furnished by the so-called synovial membrane, the structure and pathology of which we come now to consider. Every diarthrodial joint is lined with a layer of synovial membrane, except in the places where the articular cartilages are in contact. Here there is no membrane,[1] except at the edge of the cartilages, which the synovial membrane may overlap for two or three millimetres,[2] before merging into the cartilaginous structure. Fasciculi, and folds of the capsule, the internal ligaments, and fatty internal protrusions are all covered by the membrane. In the fœtus an endothelial layer is found over the cartilages, which wears off when the joints begin to be used. The limits of the synovial membrane are most easily made out in inflammation, when a red collarette is seen surrounding the white cartilages. Farabœuf[3] compares this to the chemosis in acute conjunctivitis.

Synovial membrane is thin and elastic. Externally it merges into the tissue of the joint-capsule, while its inner surface is smooth and moist. Histologically the structure is a basement tissue of elastic and connective-tissue fibres, upon the inner surface of which lies a single layer of endothelial cells (His). Hueter[4] has, however, asserted that there is no such pavement layer, but only clumps of cells here and there; but his methods of examination seem to have been at fault.[5] In gross the inner surface of a joint presents a smooth and shining surface, interrupted, especially where the membrane folds to pass from one surface to another, by the synovial fringes (plicæ synoviales)—villous structures of varying size and length, somewhat resembling intestinal villi, the largest being perhaps one centimetre long. These fringes were thought by Havers,[6] who described them, to be true glands, and he called them mucilaginous glands. Subsequent anatomists disputed this, but Rainey[7] found them in structure to be secreting organs. They are richly supplied with blood-vessels, for each villus contains the convoluted twig of an artery. Some of the fringes, however, are merely hernia-like protrusions into the joint of small masses of fat[3] covered by membrane; these fill up unoccupied spaces. The nerves are derived from the same nerve-trunks that supply the muscles of the limb. The nerve-filaments terminate in small plexuses, unequally distributed, under the synovial membrane. The lymphatic network is not easily demonstrated, but that it exists is evident from the fact that coloring matter injected into the joint disappears very quickly, to reappear in the lymphatic channels of the limb.

Synovia is a clear, alkaline fluid, much like the white of egg in general appearance; when rubbed between the fingers it imparts an oily sensation. It is largely secreted by the cells which cover the synovial fringes. In structure it contains albumen, mucin, some fat, leucocytes, and epithelial cells. A fluid identical in composition with synovia can be produced by rubbing up a portion of the epidermis in a weak alkaline solution. This fact suggests[8] that most of the mucin is derived from the endothelial cells soaking in the weak alkaline fluid secreted by the fringes, and this view is strengthened by the fact, discovered by Frerichs,[9] that, when joints are quiet, the synovia in them contains only half as much mucin as when they are in motion.

Pathology. The classification of acute inflammations of the synovial membranes is best made, on a simple pathological basis, according to the following scheme:

(1) Synovitis with effusion—serous, purulent.

(2) Synovitis without effusion, dry or plastic synovitis.

Acute serous synovitis is the most common of all. The pathological process is simple and typical; for some known or unknown cause, a joint, most frequently the knee, becomes the seat of an inflammation which is manifested in the usual way. There are hyperæmia of the vessels of the membrane, an increased rapidity of the blood-current, and then dilatation of the capillaries, with stasis. Migration of the white corpuscles from the vessels follows, and a profuse serous secretion is poured out from the dilated vessels into the perisynovial tissues and into the joint. The endothelial cells are very rapidly produced, and are cast off, half formed, into the joint. This process, carried far enough, constitutes "catarrhal synovitis," a purulent form. To the naked eye the surface of the membrane is seen to be bright red, from the dilatation of the surface capillaries; it is not so shiny as usual, and has ordinarily a boggy, softened, œdematous appearance, from infiltration, which is most noticeable in the synovial fringes. Here and there, especially in the more acute cases, may be seen a patch of extravasation, where a distended blood-vessel has burst. The fluid in the joint is often colored more or less red by these extravasations. The cartilages in an inflammation of this grade are not affected, but are seen to be of a clear bluish-white color, and surrounded by the sharply marked line of inflamed synovial membrane.

The joint at this stage is more or less distended with an abnormally large amount of synovial fluid, at first thinner than usual, on account of the copious effusion of serum into the joint, then becoming more or less opalescent as the endothelial cells are cast off into it and become macerated, and as the leucocytes increase in number. The amount of fibrin in the fluid varies greatly; in severe acute attacks the amount is generally so large that the fluid is glairy and sticky, and, on standing, distinct flocculi separate out and float around. When there is so much fibrin in the joint-fluid that it consolidates on the synovial surfaces, the case belongs rather to the class of dry synovitis. At this stage, unless it become chronic, the inflammation subsides, or goes on to the formation of a purulent exudation. If it subsides, the blood-supply diminishes, the newly formed capillaries are obliterated, and the distended ones resume their normal calibre, the cell-proliferation ceases, the cells already thrown off furnish mucin to the synovia, the excess of fluid is absorbed, and everything returns to a normal condition. The synovitis is cured.

If, however, instead of undergoing resolution, the joint-inflammation takes on a more active, perhaps a more destructive, character, we have soon to deal with a purulent effusion. Cell-proliferation and the migration of leucocytes become so prominent a part of the process, that where there was formerly serum there is now a sero-purulent or purulent fluid. From being simply red and glazed the synovial surface becomes velvety in appearance, and the cartilages become yellowish-white and their surface is indistinct and covered with lymph and flocculi of pus. In some cases the destructive process seems localized, and ulcerations of synovial tissue, and even of cartilage, take place, while the surrounding parts show only a moderate grade of inflammation. From this it is easy to see how any amount of mischief may result. The whole synovial membrane may become granulating tissue, the cartilage is perhaps eroded also, the bone is bare, and the periarticular tissues become the seat of abscesses as soon as the capsule breaks, perhaps before. It is hard to set a limit to so destructive a process as this. Two grades of this purulent effusion are properly recognized: One, called purulent synovitis, where the pus is secreted by the surface layers of the membrane and no deep-seated lesion results; this is the "catarrhal inflammation" of Volkmann,[10] and often appears to lack any serous stage. It is said to be rather "the perversion of an excessive secretion than an inflammatory tissue-degeneration." The second grade is called suppurative synovitis, and it signifies that the deeper layers of the membrane are involved.

Recovery from purulent synovitis may be complete, and no trace of the mischief may be left behind. Recovery from suppurative synovitis generally, although not necessarily, means a joint impaired by adhesions. On the other hand, as we have seen, there is no limit to the destructive possibilities of suppurative synovitis; complete disorganization of the joint, dislocation of the bones, and, worst of all, systemic infection are only too apt to follow.

Dry synovitis, arthro-meningitis crouposa, is a very obscure affection pathologically. There is an absence of much fluid, as the name implies, and the synovial membrane is covered with a dry, leathery coating, which appears to be the deposition from a slight exudation, very rich in fibrin, into the joint. Anchylosis of the joint may follow with surprising rapidity. This form of synovitis is much more common in the sheaths of tendons than in the joints. Hueter[11] believes that suppurative synovitis often results from this, and he prefers to call it synovitis sero-fibrinosa.

Symptoms. In few pathological conditions are the four classical symptoms of inflammation more marked than in acute synovitis. Pain, heat, redness, and swelling comprise a large part of all that can be said of it. First, in simple acute synovitis: A few hours after the receipt of a wound or blow, some wrench, some exposure, or over-exertion of a joint, commonly the knee, an uneasy, hot feeling is noticed, and before long it becomes a positive pain. This is associated with a tense, burning feeling and a sense of helplessness in the affected limb. Any motion adds to the discomfort, and manipulation of the joint, if carried to extreme flexion or extension, causes pain; sometimes any motion at all is painful. The feeling of distention that accompanies the height of the effusion may be distressing, but from the sixth, seventh, or eighth day, when this height is reached, the pain rapidly subsides. The pain is ordinarily felt in the joint that is inflamed, but it may be "reflected" to some other joint supplied by the same nerve-trunks. This curious phenomenon is most frequently noticed in hip-joint inflammation, where the pain may be referred to the knee of the affected side. The intimate relations and anastomoses of the sciatic, obturator, and anterior crural nerves seem to furnish the best explanation of this, although Bonnet thought it due to the position of the patient, lying in bed with the leg rolled over on its outer side, a consequent strain being put upon the external lateral ligaments. Wright says that there are three factors in this knee-pain: (1) The nerve-relations mentioned above; (2) sympathy between the ends of the bones; (3) muscular spasm. When the synovitis becomes purulent, or is so from the first, pain is a more prominent symptom and much more severe than it is in simple synovitis. If it goes on to destruction of the joint-structures and to osteitis, the pain becomes extreme, and the patient is waked from sleep at night by the muscular jerks (starting-pains), which press the inflamed and ulcerated joint-surfaces together. Even in simple synovitis the pain is worse at night.

Pain.

Tenderness. Along with the pain goes tenderness in most cases, as one would expect from the inflamed condition of the synovial sac and the irritable state of the articular nerves. Hyperæsthesia of the skin is especially present in pyæmic synovitis, but the ordinary tenderness is the pain felt on deep pressure and manipulation of the inflamed joint. There is a spot in each joint where tenderness is apt to be especially marked: In the knee it is over the inner condyle, about a finger's breadth inside of the inner border of the patella; in the ankle-joint, in front of the outer malleolus; in the hip, behind the great trochanter. The pain meantime is by no means localized, but there is a bruised, helpless feeling extending to the whole joint. Certain cases, however, are characterized by severe local pain and tenderness in some one spot, and these cases are considered by Volkmann[10] to be due to the deposit of a

fibrinous clot on the synovial membrane at that spot; the theory, however, lacks anatomical proof.

In simple serous synovitis intra-articular swelling begins on the first, second, third, or fourth day. It is of **Swelling.** two kinds—effusion into the joint and effusion around the joint. In simple synovitis the infiltration into the periarticular tissues is slight, but if pus appears the skin becomes red and boggy, and it is seen that serum has infiltrated into the tissues around the joint. The same is true of the periarticular infiltration associated with acute rheumatism, where the periarticular infiltration makes a shapeless and puffy joint; whereas intra-articular distention betrays itself by a characteristic shape in each superficial joint, dependent upon the elasticity of each synovial sac. This intra-articular distention varies from a small effusion up to a condition in which the skin is shiny, tense, and pale, and the venous return from the lower segment of the limb may be so much impeded that the superficial veins stand out as if ready to burst; or an exudation may take place from the obstructed and overfilled vessels and produce a most marked œdema of the foot and ankle. The capacity of the sac of the knee-joint, when extremely distended, is some six or seven ounces; in average cases of simple synovitis it holds about four ounces. The average capacity of the shoulder-joint sac is three ounces.[8] But in the deeper joints swelling may not be discoverable; in the hip, for instance, there may be no such signs of articular distention to be found, or the soft parts in front of the joint may be full and prominent, and sometimes fluctuation may be felt through the joint.[14] The common state of affairs in both hip- and shoulder-joints acutely inflamed is a general enlargement of the joint, without the clearly articular shape to be seen in the knee and elbow, for instance.

Redness and heat are less constant and less important symptoms than pain and swelling. Redness is not often present in simple synovitis, especially when **Redness and heat.** there is much effusion; in such case the skin is apt to be paler than normal, from the pressure upon the skin and superficial blood-vessels by the distended capsule. Pyæmic, gouty, or rheumatic synovitis is apt to be attended by a blush, which is generally quite marked in the two latter affections. In the case of the deeper joints redness as well as heat is ordinarily absent. More or less local heat about the inflamed joint is present. In an acute serous synovitis the rise of local temperature is, according to Barwell, from 1.5° to 2.4° F. above the normal. If the synovitis is purulent or suppurative, the local rise of heat is as great as in any acute purulent inflammation.

When in a state of acute inflammation a fairly constant abnormal position is assumed by each joint; the **Position.** semiflexion of the knee in knee-joint synovitis will serve well enough as a type. The hip is flexed and adducted or abducted, the ankle is slightly extended, the arm is carried at the side, the elbow is flexed at a right angle, and the wrist drops slightly and is somewhat flexed. Fixation of the muscles holding the joint is present at the same time, and the abnormal position is firmly maintained by them when manipulation of the joint is attempted. At first this muscular guard seems to be purely voluntary, and is only excited by the pain which movement causes, but in time it becomes involuntary, until in chronic joint disease it may be present in cases where movement causes no pain at all. Bonnet, of Lyons,[12] investigated this question of malposition in inflammation, making some experiments which have become classical, and until lately his theory met with universal acceptance. Joints in the cadaver were injected with fluid by means of an ordinary hand syringe, and Bonnet found that the limbs assumed the same positions as when inflamed during life. Solidifying injections showed also that the joint-capsule possessed the greatest capacity in these positions. So here was afforded an easy solution of the whole problem—the limb simply assumed the position in which the joint would hold the most fluid. But certain objections were urged against this theory. Bonnet's injections had been made with so much pressure that the condition of affairs in the joint was not to be compared with that in acute synovitis. And there are two very forcible clinical objections—certain cases of knee-joint disease, for example, with an extreme amount of effusion, present little or no flexion, and in the whole class of chronic tuberculous joint diseases, where the malpositions are most marked and most constant, effusion is oftenest absent or very slight in amount.[15] All this, of course, points to some second factor in originating and maintaining these positions. The explanation of Hilton[16] represents the other point of view; he says "that the irritated or inflamed condition of the interior of the joint (say the knee-joint), involving the whole of the articular nerves, excites a corresponding condition of irritation in the same trunks which supply both sets of muscles, extensors, and flexors; but that the flexors, by virtue of their superior strength, compel the limb to obey them, and so force the joint into its flexed condition." This phase of the question is elaborated a little more fully by Lücke,[17] who says that the extensors are lighter in color, and are not so well supplied with blood,[19] and that impairment of motor functions, after fatigue from electrical stimulation, is more marked in the extensors than in the flexors.[18] In summing up, Lücke offers practically the same explanation that Hilton does, saying that the patient finds it most comfortable to hold the limb in this position, all the muscles being tense and set. It is easy to see that the whole question of the position of inflamed joints is far from settled.

Atrophy of the muscles controlling an inflamed joint begins early and may be very marked, even in a simple **Atrophy.** acute synovitis. In five cases, seen by Valtat[20] from the eighth to the eleventh day of the synovitis, muscular atrophy was present in all to the extent of at least two or three centimetres. The character of the joint disease seems to matter but little in the production of this phenomenon. Traumatic or simple, acute or chronic, serous or purulent synovitis, all show muscular atrophy, and the more acute the disease, the faster the wasting goes on. That this is something more than the mere atrophy of disuse is shown by the fact that it begins so sharply and so early, that it is greater in the diseased limb than in the well one, even when the patient has been in bed from the first, and that the muscles, although atrophied, are not soft and flabby, but tense. Sir James Paget says: "I wish I could explain it better than by calling it reflex atrophy," and Brown-Séquard's experiments lead him to think that the trouble is an irritation of the nerves, and independent of the trophic centres. Valtat injected the joints of guinea-pigs and dogs with irritant solutions, mustard-oil and ammonia, and found that muscular atrophy came on quickly. In one case, in eight days there had been a loss of thirty-two per cent. by weight in the anterior thigh-muscles, and twenty-four per cent. in the anterior calf-muscles; in another case it reached forty-four per cent., and in all cases the extensors wasted more rapidly than the flexors. He attributes much influence in the matter to the amount of pain present, a point already clinically noted by Paget. **Paralysis.** Valtat also calls attention, in this connection, to the paralysis of the muscles of the affected limb often accompanying acute joint disease, the loss of power already mentioned, and also a diminution of faradic excitability after severe muscular wasting. In a case of knee-joint synovitis, which he mentions, there was complete paralysis of the flexors of the leg at the end of twenty-four hours. Such a paralysis, to a greater or less degree, seems to precede the wasting of the muscles.

The general condition of a patient with simple acute synovitis suffers but little. The rise of temperature, if **General condition.** any, is slight, unless a rheumatic condition exists, and only with the advent of pus does the temperature rise to any extent. A sudden chill, an increase of pain, a tendency to fever, all make one suspect the formation of pus, and when that has once come the general condition may become ever so bad. Gonorrhœal, rheumatic, and pyæmic synovitis are accompanied by fever and the other symptoms of the affections which they represent.

It is hardly worth while to go deeply into the symptomatology of dry synovitis. It is rare, and its clinical as well as its pathological characteristics are but ill defined. Bonnet describes it as being characterized by much fever and periarticular swelling, severe pain, with a tendency to bad positions, and rapid obliteration of the joint by anchylosis. Barwell says that the pain of synovitis with effusion is not worthy of comparison as to severity with the pain of dry synovitis, and that there is always pyrexia and a doughy look to the skin, and he, too, speaks of the tendency to anchylosis. Volkmann thinks that Bonnet confused this affection with ulceration of the cartilages. However, the fact remains that there are cases of joint disease in which pain, and not swelling, is the prominent symptom, where no pus can be found, and where anchylosis is most rapid and unexpected.

Varieties.

Considered in relation to cause, acute synovitis falls into two classes, traumatic and non-traumatic, as shown in the following schema:

Synovitis acute.
- Traumatic.
- Non-traumatic.
  - Simple,
    - From exposure,
    - From over-exertion.
    - Not to be accounted for.
  - Rheumatic,
  - Gonorrhœal,
  - Pyæmic,
  - Puerperal,
  - Exanthematous,
  - Gouty,
  - Syphilitic,
  - Secondary to neighboring disease,
  - Catamenial and metric.

Traumatic synovitis is, of course, the more common, since sprains, blows, and wounds of all sorts are likely to contribute more cases than all the rest put together (see Joints, Injuries to). The non-traumatic forms of synovitis chiefly claim our consideration here. Laying aside, then, traumatism, the most frequent causes of simple serous synovitis are exposure to cold or wet and overuse of the limb affected, and consequent direct mechanical irritation of the joint. This is often enough called rheumatic, even when it lacks the constitutional symptoms of acute rheumatism, and occurs in persons by no means predisposed to rheumatic attacks. Such cases may be rheumatic, yet they lack evidence of being so, and the term had much better be reserved for the form of synovitis, generally polyarticular, which accompanies the attacks of more or less generalized rheumatism.

Simple synovitis sometimes arises when it is impossible to assign any cause for it, and pursues its regular course; this form, too, is called rheumatic, on evidence which may be very good or very insufficient. Acute simple synovitis occurs mostly in young adults, and is more frequent in men than in women.

What should really be called rheumatic synovitis is only too familiar in acute articular rheumatism. It is serous in character, and the extra-articular swelling is apt to predominate and mask the distention of the synovial sac. It may involve one or, more commonly, several joints, and is, of course, associated with the constitutional symptoms of rheumatism; ordinarily it is a simple serous synovitis, lasting from three days to several weeks; it rarely goes on to suppuration, and it shows a strong tendency to become subacute or chronic.

Gonorrhœal or urethral synovitis stands half-way between the rheumatic and pyæmic varieties, and possesses some features of each. It occurs oftenest in the second week of an acute urethritis, and ordinarily attacks the knee, but no joint is exempt. It generally attacks one joint at a time, but it may be polyarticular. It may come on acutely, with fever and much pain, or it may begin insidiously and pursue a more chronic course. It is occasionally found in women, but is very much more rare in them than in men.[23] The manner of its relation to gonorrhœa is not known; the doctrine that it was a metastasis is no longer held, nor does the suggestion that it is due to a mild purulent infection meet with much acceptance. It may even follow the passage of a sound, or some urethral irritation where no gonorrhœa exists;[24] ordinarily it is serous, and is stubborn and painful; sometimes, though rarely, it becomes suppurative, and simulates pyæmic synovitis very closely.

Pyæmic synovitis is characterized by the rapid formation of pus in a joint, ordinarily the knee, ankle, or shoulder; and the inflammation of this joint is apt to be followed by that of several others, involved in rapid succession. The serous stage is generally unnoted, although it is probably present. Associated as this affection is with general pyæmia, there is little to be expected that is favorable. The destruction is generally rapid and extensive, and the pus which is evacuated may be thin and foul, or thick and flaky. Formerly a separate class was made of puerperal synovitis; but since the nature of puerperal fever has been recognized, this form naturally falls under the class pyæmic, where its symptoms entitle it to a place. It is apt to be milder, however, than ordinary pyæmic synovitis. A class of pyæmic joint-affections in new-born children, resulting from infection from a suppurating cord, has been described by Mildner.[25]

Cases of synovitis sometimes follow the exanthemata and typhoid fever. Of the exanthems, not even varicella is always exempt, but scarlatina and measles are most likely to leave joint-complications. The synovitis ordinarily comes on during convalescence, and the frequency with which chronic tubercular osteitis is found after the exanthemata[26] suggests the possibility of the transition of the acute synovitis into this affection; ordinarily it is a serous synovitis, almost always polyarticular, and although it usually simulates rheumatic synovitis and is mild, it may become suppurative and follow more closely the course of the pyæmic affection. Fortunately, inflammations of this class are rather rare; an idea of its frequency in typhoid fever may be obtained from the statistics of Güterbock,[27] derived from 3,130 cases treated at the Vienna Hospital from 1868–71, where only 2 cases of joint-complication were noted. And Barwell could find no joint-complications on record in the London Fever Hospital.

Gouty synovitis is the local manifestation of the general disease. It is a serous synovitis, ordinarily of the great-toe joint, with considerable periarticular infiltration and redness of the skin. It tends to involve other joints in succession, and there is at the same time going on a slow change in the joint—alteration of the cartilages, and a deposit of urate of soda in them—and finally erosion of the cartilages down to the bone, with obliteration of the joint. In short, there is a chronic structural change in the joint, which is merely interrupted by these attacks of acute synovitis.

The occasional occurrence of clearly marked acute synovitis, either monarticular in the knee, or polyarticular, is noted in the febrile stage of syphilis.[28]

There is a class of cases of acute purulent synovitis which can be best designated as synovitis from direct infection. Such cases occur in acute periosteitis, acute osteomyelitis, chronic osteitis, and periarticular abscess, in all of which the disease is apt to be located near the ends of the bones. In periosteitis the pus collecting under the periosteum may break through and escape externally, or burrow along to the joint and enter it. In the latter case, of course, an acute purulent inflammation of the joint immediately starts up. Osteo-myelitis, in its destructive course, is likely enough to reach a joint and the pus to enter it, when the same purulent infection will occur. In chronic osteitis of even slight extent a tubercular nodule may have formed in the epiphysis near the joint-surface; it softens and breaks down, and, instead of passing into the outside tissues, the pus follows the line of least resistance and reaches the joint by perforation of the cartilage. The chronic symptoms light up with a fresh accession and an acute synovitis is clearly present. There seems, also, reason to believe that an acute synovitis may be secondary to a chronic abscess, probably tubercular in character, which in its course reaches and enters the joint-capsule. These last four classes of cases are, of course, merely secondary and incidental to a chronic and much more important disease, but they deserve mention.

Under miscellaneous cases should be mentioned what Barwell calls catamenial and metric synovitis, a multiple synovitis which he considers analogous to the urethral synovitis of men. It occurs (1) in pregnant women; (2) a month to six weeks after labor in women who have not had puerperal fever; (3) in non-pregnant women in connection with menstrual irregularity or suppression. Mr. Thomas Smith calls attention to a peculiarly destructive form of synovitis in infants, which he calls "acute suppurative arthritis." It ordinarily begins from the synovial cavity, but not always, and its origin is neither traumatic nor syphilitic.

Diagnosis.

First, as to the diagnosis of synovitis with effusion: The swelling produced by the distended capsule is the most characteristic sign; it is irregular in outline, bulging, and fluctuating, where the joint is superficial. In the ankle-joint the swelling is not very clearly marked, but it ordinarily is chiefly anterior and the capsule bulges out in front of the malleoli. In the knee the patella is lifted by the effusion, and floats. In examination for this the fingers of both hands should encircle the limb firmly in front, above and below the patella, thus confining the effusion to the space directly under the patella and over the intercondyloid depression on the femur. The forefinger of one hand then lightly but sharply presses on the patella, which can be felt to descend and hit the femur. This matter of fully extending the leg and grasping it is of much importance, as otherwise a small effusion may escape detection. Acute synovitis of the hip is a rather obscure affection, and in children the diagnosis is not generally possible. In cases with much effusion in adults, however, swelling may be found in the groin above Poupart's ligament and behind the great trochanter. In the case of the shoulder the whole joint is larger than usual, without any definite outline; and if the distention is great, the axilla may be more shallow than normally, and the depression beneath the acromion behind is lost. In the elbow there is bulging of the sac behind on each side of the triceps tendon. The wrist, when inflamed, shows an encircling swelling. The positions assumed by the various joints, when inflamed, have been given above, but simple position is of little service in differentiating synovitis from other joint- and bone-affections, and the same is true of muscular atrophy. Synovitis is to be distinguished from osteitis, bursitis, articular neuralgia, and hysterical joint disease. A diagnosis of acute synovitis in children should be made with very great care, for they are not prone to have acute synovitis, and are very prone to have chronic osteitis. The diagnosis, for example, between acute synovitis of the hip and morbus coxarius can ordinarily be made in the case of adults, but in children the diagnosis of an acute synovial inflammation of the hip should be made only after permanent recovery has followed, in a few weeks, upon the symptoms caused by an injury, not at the time of the acute symptoms. Let anyone read the symptoms of acute hip synovitis, as Gibney,[26] *e.g.*, gives them, and see which of them, except speedy recovery, is not compatible with hip disease. Suppose that a tubercular focus has been formed in the epiphysis of the femur near the joint, when the pus reaches the joint, just as likely as not after some fall, of course an acute synovitis is set up, as we have seen. That may be the first symptom in the case,[30] and if a diagnosis of primary acute synovitis is made, as the symptoms would seem to warrant, it is a serious blunder. The same is true of all the joints, when children are to be considered. There are cases of primary acute synovitis in children; they are not common, to be sure, but no attempt is made to deny their existence; simply the practical diagnosis cannot ordinarily be made. Typical bone disease begins with stiffness of the joint, pain—especially at night, interrupting sleep—wasting of the muscles of the limb, and absence of effusion. With regard to the chief diagnostic mark of typical synovitis I quote from Mr. Bryant: "Any inflammation of the synovial membrane, of whatever kind, always shows itself within a few days or hours of its origin, by effusion and consequent distention of the articulation."

From bursitis, synovitis is distinguished by the different location of the swelling, the less degree of joint-stiffness and pain, except when manipulation bears directly on the inflamed bursa, and the absence of muscular atrophy. In the case of deep bursæ the differential diagnosis may not be easy at first. Bursitis, however, rarely begins without cause; it is associated oftenest with mechanical irritation, as the names "housemaid's knee," "miner's elbow," etc., show. It should be remembered, however, that bursæ often communicate with joints, and that synovitis and bursitis may exist together during an acute synovial inflammation. The bursæ, when inflamed, form in their way as characteristic a swelling in each joint as the joint-capsule itself, when distended by intra-articular effusion. The two are easily distinguished. Articular neuralgia is said to exist apart from joint disease.[32] The pain is out of proportion to the local symptoms, heat and swelling are not present, cutaneous hyperæsthesia generally is, and so, possibly, is muscular fixation.

Hysteria simulates chronic oftener than acute joint disease, yet sometimes, following a fall or an over-exertion, sensations closely simulating the symptoms of an acute synovitis may be complained of. Ordinarily the diagnosis is easily enough made by the absence of heat, swelling, and localized tenderness, and by the general make-up of the patient, but some cases offer much difficulty, as muscular wasting and rigidity may be present to a marked degree.[33] Pyæmic, gouty, and rheumatic synovitis are easily to be distinguished from each other by the presence of the constitutional affections of which they are merely the symptoms, while urethral synovitis often offers some little trouble from the fact that the patient is anxious to conceal his urethral discharge. Rheumatoid arthritis belongs rather to the class of chronic joint diseases, and would hardly be confounded with acute synovitis.

Finally, as to the diagnosis of dry synovitis: Its acuteness, severe pain, and the absence of swelling are its leading characteristics. To diagnosticate it from osteitis would be sometimes impossible, but ordinarily its more acute course will establish its identity. From the other affections it can be more easily distinguished by the methods mentioned in the section on the diagnosis of synovitis with effusion.

Prognosis.

The prognosis in simple serous synovitis of traumatic or non-traumatic origin in adults is good, if the general condition of the individual affected be even fair. Suppuration is not common, except from wounds; and when it occurs, there is generally some evident cause for it, such as infection by tapping, a broken-down constitution, etc. Under effective treatment a complete restoration of the joint is the rule. From the sixth to the eighth day the effusion will ordinarily begin to subside, and its absorption is much aided by pressure and rest. The third possibility in a simple synovitis is that it may become chronic. In some cases the swelling does not subside much, but the pain goes away, and, although the joint remains swollen, the patient may go to business and use the leg fairly, but he has dropsy of the joint, chronic serous synovitis, or an irritability may remain after the absorption of the fluid, and succeeding light attacks may follow one another, each leaving the joint worse than it was before; these cases are apt to eventuate in chronic joint disease. Neither of these latter classes is very common in healthy adults, and the prognosis is, as we have seen, favorable, especially when, after the appearance of the effusion, the pain and fever quickly subside. Rheumatic synovitis, on the other hand, has a tendency to become subacute or chronic, and to leave stiff joints. The occurrence of suppuration in either rheumatic or simple synovitis is a serious matter, and, although prompt treatment will in most cases be efficient, the prognosis will be much more doubtful, especially if the suppuration should have come on without apparent cause. The occurrence of a joint-affection in pyæmia does not make very much difference in the outlook, for the prognosis depends wholly upon the general character of the disease, whether mild or malignant. If mild, in from

five to ten days the joint-symptoms improve, and a complete restoration of the joint is not impossible.[34] On the other hand, the destruction may go on to any extent, preceding a fatal termination. In general, however, it is not common to find complete restoration of joint-function after either purulent or suppurative synovitis, although it may take place. The synovitis occurring after the exanthemata is said to tend toward recovery after a few days. At the same time, bearing in mind how often chronic joint disease follows these exanthemata,[35] it is best not to give an unreservedly favorable prognosis. The form occurring in typhoid fever is generally purulent and more grave. Gouty synovitis, when left alone, lasts from a week to ten days; efficient treatment will generally shorten its course to three or four days. Gonorrhœal synovitis is at best a slow affair; it is characterized by a slow course, with a tendency to relapse and become chronic. Recovery is not common in a less time than a month or six weeks.

The occurrence of synovitis as a complication in chronic osteitis is merely an incident in the course of a long disease.

Treatment. The important points in the treatment of acute synovitis are to put the joint at rest and to keep it so, and, secondly, to put it at rest in good position, so that if anchylosis should take place, as useful a limb as possible would be obtained; that is, the knee should be put up very slightly flexed, the elbow at a right angle, with the thumb upward, the hip very slightly flexed on the trunk and neither adducted nor abducted, the ankle at a right angle, the wrist in the line of the arm, and the shoulder with the arm at the side. The splint that offers the most definite and absolute support to the two limb-segments is to be chosen. Ordinary wood and tin splints, accurately padded and firmly applied, are generally the most serviceable, except in the ankle, where in severe cases carved wooden side splints often will not answer, and wet millboard or plaster of Paris must be applied; and in the hip, where bed-extension and a long outside splint, as in fractured thigh, will be most serviceable. Millboard splints are applied according to the directions of Gamgee.[36] The joint is wound by rollers of sheet-wadding until one or two layers cover it everywhere, then wet millboard is shaped to the joint and bandaged on by linen rollers, applied with firm, even compression, which may be considerable if the method is properly applied. Plaster of Paris splints are made by the application of crinoline-gauze bandages impregnated with finely divided plaster. The limb is first wound in sheet-wadding, and then the plaster rollers are applied. The method does not give in all cases certain, definite support. I quote from Dr. Judson[37] in regard to it. He says: "It may be an exaggeration, but it conveys the idea, to say that a plaster of Paris or silicate splint, applied to the leg and thigh, contains a mass of jelly in which the femur is but little restrained from motion."

The problem of getting a limb into good position for the application of a splint is not always an easy one. The knee, for example, is apt to be more flexed than is desirable, especially in a case of some days' duration; and if easy manipulation fails to bring it into correct position, recourse must be had to manipulation under ether, or extension by weight and pulley, before a ham-splint can be applied. Unless there is some strong reason to the contrary, the latter of the two methods should be chosen, and the muscles which maintain the flexion of the joint will be found to yield with surprising readiness to continuous extension, with even so small a weight as three to five pounds, counter-extension being obtained in the usual way, by raising the foot of the bed. Once obtained, this good position is easily kept. This extension method also relieves the pain and discomfort surprisingly in severe cases, whereas manipulation under ether is ordinarily so painful that opiates are required after it. It is not generally practicable to apply extension to the wrist or ankle. The plan of putting up the limb in whatever position it happens to be, and waiting for it to straighten under rest, is neither safe nor always effectual. With the larger joints rest in bed should be enforced. This treatment should be the same, whatever the origin or the character of the synovitis, with the one exception of that following penetrating wounds of the joints. Here cleanliness takes precedence of everything. If the opening is not already large enough through which to wash out the joint, it should be made so, and the whole joint thoroughly irrigated with 1 to 5,000 corrosive sublimate solution, or 1 to 30 carbolic acid; no means should be neglected to remove all foreign material from the joint, then the case should be dressed antiseptically and treated in the usual way.

Having then put the limb into good position, and having fixed it so, less important matters are to be considered. A simple synovitis of moderate severity may practically be let alone, after applying some compression to the distended sac. A flannel bandage, cut bias, to give the full elasticity of the cloth, affords light compression; small dried sponges, laid over the joint and held in place by stout linen rollers, and then wet, afford either the lightest or the most severe compression. The application of a rubber bandage is one of the most common forms of producing compression. It can be loosely applied and produce but light pressure, or by stretching it only slightly during its application very severe compression may be obtained. The objections to it are the macerating of the skin under it, and the tendency thereby induced to erythema and eczema, and also the fact that it must be very lightly applied, for with much tension the discomfort is likely to become unbearable a short time after application; but when properly used it is often of the greatest benefit. The method of Gamgee, above alluded to,[36] is applicable to almost any joint, and affords even, comfortable, and efficient compression. If, however, the intra-articular distention is extreme, or if at the end of a week it does not begin to diminish, the joint should be aspirated and compression at once applied. Dr. H. A. Martin said:[38] "I have never known a case where a joint was 'aspirated,' and no such support [as the rubber bandage] afterward applied, in which the effusion *did not return*, whether the synovitis was the result of injury or disease." If the aspiration is done with proper antiseptic precautions it is attended by practically no risk; simply a needle of fair size is thrust into the most elevated part of the sac and connected with a common aspirator-tube. The puncture should be sealed with plaster or iodoform collodion. The claims of Dr. Martin[39] for this method are clearly extravagant. I quote directly from his article: "(1) That in a little over nine years I have treated over one hundred and forty cases of synovitis of the knee and its sequelæ by aspiration, with a single strapping of the joint and subsequent use of the bandage. . . . (3) The patient was in nearly all cases permitted to walk about. (4) That in not a single instance had there been a failure of absolute and entire cure. (5) That in no instance had this desirable end been postponed for more than seventeen weeks," etc. The experience of other surgeons in this treatment does not coincide with that of Dr. Martin.

The application of cold to the joint often gives relief to the pain and a sense of comfort. This can be done by a poultice of ice and saw-dust, by the ice-bag, or by the rubber coil wound around the limb. In other cases warm applications are more agreeable and equally useful. Hot-water bags can be used, or poultices, or fomentations of laudanum and hot water. In any synovitis of a severe character in a full-blooded individual the application of leeches to the joint is a measure of the greatest value, especially if there is much local heat and tenderness, and a tendency to suppuration is suspected. Nor should the leeches be used sparingly; from six to twelve should be put on all over the joint, and allowed to fill themselves, and then the bleeding is either to be encouraged by warm applications or checked by cold ones, as seems most advisable. On the other hand, painting with iodine, blistering, firing, and the other forms of counter-irritation seem a needless and bothersome infliction in simple acute synovitis; if, however, it shows a tendency to become chronic, then the time for counter-irritation has come, and blisters encircling the joint, in connection with as-

piration and subsequent compression, should be made use of. When the effusion has subsided and only a moderate thickening of the tissues is left, the splint should be removed and passive motion begun at the earliest possible moment, along with massage; for the tendency which inflamed joints have to become anchylosed should always be borne in mind. The experiments of Moll[40] did but little to clear up this question of anchylosis; for although from them it was perfectly evident that a sound joint might be immobilized indefinitely without losing any of its mobility, yet when inflammation of the joint was present, from a fracture near it, Moll was unable to say in what proportion of cases anchylosis occurred, although the joint was obliterated in several of the animals experimented on. As to methods of manipulation and massage,[41] a skilled masseur is, of course, the best person to handle the limb, but deep kneading of the muscles and gentle flexion and extension of the joint, increasing in extent each day, answer every purpose. The muscular atrophy will cause the limb to be weak; and, if it has been severe, although it would probably recover itself, restoration can be hastened by the use of a weak continuous current, perhaps of the faradic also.[20] It is not worth while to attempt to use the limb very much until its function is fairly well restored by passive motion. The use of palm-oil, etc., is, of course, much inferior to massage with the dry hand, but if the pain persists, on using the limb, stimulating liniments and blisters are very useful. If anchylosis should have already taken place, there are two methods to pursue: (1) To break it up at once under ether, a method which will ordinarily cause a relapse of the synovitis; or (2) to wait some months before attacking it. The latter method will generally be advisable. The constitutional treatment of acute serous synovitis amounts to nothing more than the routine of keeping the bowels open, and administering diaphoretics if the temperature is elevated. If, however, there is any reason to suspect a rheumatic cause for the attack, salicylate of soda should be given in full doses.

When the formation of pus in a joint is once established, there is ordinarily only one treatment to be considered, namely, incision. When the skin over the joint becomes red and œdematous, and the pain more severe, and when the patient is feverish, a full purge should be given, the joint should be kept absolutely quiet, and leeches applied in abundance, followed by cold and light compression. If, now, the trouble increases and fluctuation is apparent, the introduction of an aspirating-needle will show pus in all probability, but aspiration will rarely give more than temporary relief. The joint must be opened by a free incision, made under every antiseptic precaution, thoroughly scrubbed out with corrosive sublimate or carbolic acid solutions, freely drained, and put into a desirable and fixed position, covered by a full antiseptic dressing. When the wound heals, passive motion should be begun at the earliest possible moment, in order to save as much of the joint's motion as possible. The constitutional condition of patients with purulent synovitis is not good, and should be treated by alcohol, quinine, iron, and forced nourishment. The treatment of rheumatic, gouty, and gonorrhœal synovitis is considered in the articles, elsewhere, treating of those affections. Joints affected with pyæmic synovitis must be opened, but antiseptic precautions are, of course, useless. The treatment of exanthematous synovitis should be especially watchful, and the patient's general condition should be most carefully looked after. *Robert W. Lovett.*

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SYPHILIS. The word syphilis was probably first suggested by *Syphilus*, the name of one of the characters in a pastoral poem composed by Fracastor in 1530. This name was unquestionably coined by the poet for his fictitious character, by a combination of σῦς, hog, and φίλος, fond of—a not uncomplimentary designation for a swine-herd.

Definition.—Syphilis is a specific, infectious, and chronic disorder, resulting either from inheritance or from immediate or mediate transference of the disease from an infected to a sound individual, beginning always, in the latter event, after the lapse of a characteristic incubative period, by the appearance of an initial lesion, at the site of infection, commonly termed a chancre; and followed after an interval of time by symptoms of systemic derangement, usually evolved in a determinate order, which eventually may affect any organ of the body, one attack usually conferring upon the subject of the disease immunity against subsequent infection.

Synonyms.—Many of the names which have been employed to designate the disease seem to have originated in attempts to shift the reproach of its origin and existence from the people of one nation to those of another. It has been called morbus gallicus, the French disease, lues venerea, mal vénérien, vérole (in France), sifilide (in Italy), French pox, chronic pox, "bad disorder," "bad disease," Lustseuche, Krankheit der Französen, radezyge (in Sweden), and other names. It is also said to be identical with frambœsia and yaws, but there is some doubt as to these points.

History.—Toward the close of the fifteenth century, soon after, in fact, the discovery of a new continent, syphilis made its appearance among Europeans and became the subject of discussion in medical literature. By many it was then supposed to have originated in consequence of the relations newly established between the inhabitants of the old and of the new worlds, and it was therefore often termed the "American disease." Later investigation, however, makes it appear probable that syphilis appeared among the races of men at a more remote period of antiquity. Evidence of syphilitic disease of the bones has been recognized in the skeletons of prehistoric man.

In later and historic epochs also, symptoms scarcely to be distinguished in their description from those of syphilis are described in the ancient literatures of China, Mexico, Peru, Arabia, Greece, Rome, and in the sacred writings of the Hebrews. It is probable that, at the periods which have been assigned for the origin of the disease in the fifteenth century, its rapid extension was largely due to the awakened activities of mankind in the direction of geographical discovery and international traffic. It is a well-known fact that epidemics of infectious diseases are usually most severe in communities which have long been virgin of such accidents.

The literature of syphilis may almost be said to date from the period so long assigned as that of its first appear-

ance among the races of men. It has since been adorned by the names of such eminent medical authors as Astruc, Van Swieten, Boerhaave, Bell, Sydenham, Colles, Hunter, Ricord, Gross, and Bumstead. The contributions to the subject made by contemporary authors have been as voluminous as valuable. The evolution and involution of the syphilitic process in every organ and tissue of the body have been observed and described with as much detail and accuracy as have been bestowed upon any of the problems in medicine.

Geographical Distribution.—Syphilis exists to-day in almost every country to which commerce has pushed its ventures. The degree of its depredations in any province may be wellnigh regarded as a measure of the extent of the intercourse of the inhabitants of such a country with the world at large. It exists in Great Britain, Russia, France, Italy, Norway, Sweden, Denmark, Prussia, Austria, Portugal, Switzerland, and in every other country of Europe. Its victims are usually more numerous in the larger centres of population where the activities of trade are greatest. England, for example, with her enormous maritime traffic, pays a heavier price of this character for her commercial profits than France, which is popularly supposed to suffer in larger measure. In a few of these countries, Italy, for example, where many of the people are densely ignorant, filthy, and poor, epidemics of the disease have occurred with disastrous results. On the African coasts, in Egypt, Madagascar, and Abyssinia; in all countries of Asia with which Europeans sustain commercial relations; in Japan, where the disease is reported to be both widely prevalent and virulent; in the Levant; in all parts of Asia Minor, and throughout all districts lying upon the shores of the Black Sea, syphilis is found, varying both in types of intensity and in preponderance. The same is true of all the countries of North and South America, Oceanica, and the Sandwich Islands. In the United States of America, syphilis may be recognized in every hospital and in the practice of almost every physician of repute. It is fortunately, however, much more common in the large cities, the rural populations escaping to a happy extent. It is found here among those who are native to the soil, including the negroes and Indians, as well as among the Chinese and other individuals of foreign birth who have immigrated hither.

It appears, in brief, that the extent and severity of the disease are not related to climate, isothermal lines, or degrees of latitude and longitude. They are intimately related, rather, to certain social traits in mankind, distinguished in their commercial, military, and religious excursions, trading ventures, pilgrimages, wars, fairs (*e.g.*, that of Nijni-Novgorod), and encampments of armies; their hygienic and medicinal methods; and, more or less in consequence of what precedes, to the density of population and the degree of intelligence possessed by infected classes as displayed in their management of the malady.

Nature of the Disease.—Syphilis is a specific infectious disease, always occurring in consequence of transmission from a diseased to a sound individual, and always transmitted as such. It does not sustain etiological relations with scrofulosis, tuberculosis, leprosy, or any other known disorder. It is capable of transmission by inheritance, and also by the medium of fluids furnished by the pathological tissues of diseased individuals. These fluids when isolated may be said to embody all the power and potency of the disease, and hence are described as virulent, or containing the virus of syphilis.

This virus, or contagious element of the secretion, which may be removed from one individual and artificially introduced into another with the result of thus producing the complete evolution of the symptoms of the disease, has been the theme of much discussion. Its very existence has been doubted by Bru, Jourdan, and others. Chemical analysis has failed to isolate it. Salisbury, Lostorfer, and others, have thought they discovered the germs of the disease in this secretion, but failed to make good their pretensions. Later, Pisarevski, Klebs, Bermann, Aufrecht, Morison, and Birsch-Hirschfeld, have discovered, in fluids of this kind, micrococci, which by them were supposed to be the etiological factors of the disease. Finally, on November 12, 1884, Lustgarten announced to the Vienna Society of Medicine that he had recognized the bacilli of syphilis. They were somewhat smaller than those of tuberculosis, from two to seven thousandths of a millimetre in length, and about three thousandths of a millimetre in width, straight or curved, and isolated or grouped, with contents distinguishable in the form of from two to four light, ovoid, colorless points supposed to be spores. While Doutrelepont, Klemperer, and others have verified these observations, it is held by Cornil that the microbe, supposed by Lustgarten to be the essential element of the syphilitic virus, was indistinguishable in more than one-third of all chancres examined by him and his collaborators; while Koebner asserts that, though these organisms are recognized in most of the genital lesions of syphilis, they are not found in buccal and other extra-genital lesions of the same disease. The claim is also put forward that they are more or less identical with the bacilli which can be recognized in normal smegma. Lastly, it is admitted that the essential conditions requisite to establish the fact that any micro-organism is the sole factor in syphilis have never been satisfactorily met. These are: The fairly constant demonstration of the bacilli in lesions of syphilis, whether occurring in one or another region or viscus of the body; next, the reproduction of generations of these germs in sterilized culture-fluids; lastly, the infection of sound human beings by the medium of the latter, and the production in such infected subjects of a typical syphilis, capable of transmission to a sound individual by the usual methods.

In the absence of positive data of this kind, we are not, however, left for an explanation of the nature of syphilis to such mazes of speculation as were the only resource of the earlier writers on this subject. Though unable to declare to-day that this or that specific germ is the essential factor in the disease, the remarkable advance of knowledge on the subject of bacterial affections gives us a basis sufficient to establish the belief that syphilis belongs to the class of infectious granulomata; and is the result of the introduction of a parasite into the human economy. The disease should be classed to-day with tuberculosis and leprosy, whose etiological bases are now scarcely questioned; and, possibly, also with glanders, mycosis fungoides, actinomycosis, and other affections with respect to whose precise bacterial relations there is some doubt.

Neisser, in fully accepting the consequences that follow the acceptance of this position, established by analogy but unsupported by demonstrable fact, has in this light satisfactorily explained many of the phenomena of syphilis. The bacteria may be transmitted by intra-uterine inheritance or extra-uterine infection at a given point where multiplication of the germs occurs. Whether instantaneous general infection follows by the sudden admission of these micro-organisms into the circulating fluid; or by the slower process of invasion of the lymph-channels and extension through the lymph-glands to the general economy, it seems clear that the initial sclerosis of the disease, a "chancre," becomes a focus of infection which only gradually participates in the same process of distributing the germs of the disease throughout the general economy. Later, the lodgement of these germs in various parts of the body determines the development there of the specific products of the disease; possibly also exercises there that specific local modification which renders the tissue then capable of reacting in a certain characteristic morbid behavior, after the operation of external irritants (mucous patches in the mouth of the smoker, etc.). Neisser believes that the nearer the date of infection, the larger the number of bacteria present at any one moment in the body; and, as a corollary from the above, the more numerous, symmetrical, and superficial the lesions. But in later periods, with a smaller number of bacteria and a gradual decrease in capacity for infection and hereditary transmissibility, there are fewer, deeper, more asymmetrically disposed, and more malignant manifestations of the disease.

Evolution of the Disease in Periods.—Every case of acquired, as distinguished from inherited, syphilis begins with a chancre. Cases reported to have originated in other ways are to be regarded as instances of unrecognized chancre. In popular phraseology, the period of the disease during which are displayed the local phenomena of the chancre and its characteristic adenopathy of contiguous lymphatic glands is termed the period of primary syphilis. The period of so-called secondary syphilis is that which begins with the earliest symptoms of constitutional, as distinguished from purely local disease, and whose symptoms are, for the most part, as regards cutaneous manifestations, both symmetrical and superficial. Not only the skin and its appendages (nails, hair, etc.), but the eyes, lymphatic glands, and other organs may be affected in this period of the disease. It rarely begins as early as the twenty-fifth day after the appearance of the chancre; and is even more rarely postponed to the sixth month after such appearance. No definite term of duration can be assigned to its manifestations; hence the limit between so-called secondary and tertiary syphilis is of artificial importance and of variable date. Secondary manifestations in syphilis usually cease to occur after the second year of infection, but may be displayed for a year or more afterward.

So-called tertiary syphilis includes the later lesions of the disease, graver in type, deeper, often visceral in situation, and possibly single, usually asymmetrical in development. They may be evolved as early as the third or fourth month following the primary lesion, and persist or recur during a series of subsequent years. In exceptional cases there is a reversal of the order of evolution indicated by these popular phrases, first employed with precision by Ricord, so that so-called secondary syphilitic symptoms succeed the so-called tertiary. In tertiary syphilis the subcutaneous, osseous, fibrous, nervous, and other tissues of the body are affected, together with the viscera.

For a study of the symptoms displayed in the period of primary syphilis, the reader is referred to the admirable and complete article, entitled Chancre, to be found in the second volume of this work. In the pages which follow, syphilis will be considered from the earliest of its constitutional manifestations throughout its career, beginning, therefore, with the so-called secondary period.

The Stage of Invasion of Systemic Syphilis.—After the appearance of a chancre, from forty to fifty days usually elapse before the appearance of the first syphilitic eruption. This period may be shortened to three weeks; and, in exceptional cases, prolonged to several months. There is strong reason to believe that it may be prolonged under the influence of mercury. In it the chancre commonly progresses from complete evolution to involution; and, when there has been ulceration of that lesion, to cicatrization. Usually, also, when ten or fifteen days only of this period have elapsed, the adenopathy connected with the chancre has appeared and reached its full development. With the chancre healing or cicatrized, and with one or several of the neighboring glands, possibly their lymphatics also, in a state of painless induration, the concluding three-fifths of this period is one of apparent inactivity of the disease. It has been called for that reason a second incubative period of the disease. In the view of the inexperienced, the subject of the disease at this time may be possibly regarded as in a condition of health. Careful examination, however, reveals usually the following significant symptoms:

(a) *The Chancre Features.*—If the chancre be examined it will be found, if recognized at all near the conclusion of the period, either ulcerated, cicatrized, represented by a sclerosis, or preparing for transformation to a lesion of secondary syphilis. Sometimes a deeply ulcerated and formidable chancre persists as such till the complete evolution of secondary syphilis; oftener, before the date of such evolution, a previous ulceration has resulted in a tender cicatrix surmounting one of the several grades of induration which characterize the primary lesion. In yet other cases, without any distinct ulceration, the characteristic sclerosis of the disease persists (upon the genital region, finger, lip, etc.), ranging in bulk from a parchment-like thickening to a large nut-sized semi-solid mass usually freely movable upon the tissues beneath. Careful search for this sclerosis in every suspected region should be made in all first examinations of a patient at this period. In yet other cases the chancre is represented by an erosive lesion capping any form of sclerosis which, participating in the process of systemic evolution of symptoms, soon exhibits an elevated floor which may be covered with a whitish pellicle resembling the surface of a mucous patch, and be thus in fact changed to a true granulating mucous patch, the so-called transformation of chancre *in situ.* In all or any of such events, just prior to the evolution of secondary syphilis, there is often a marked, pathological activity of some sort in the chancre-site, the sclerosis becoming larger, the declining maculopapule more vivid, the ulcer deepening or reopening, or the superficial erosion becoming a smooth, granulating surface with an opalescent pellicle spreading over its area.

(b) *The Lymphatic Glands and Vessels.*—With very few exceptions one or more, usually several, of the lymphatic ganglia nearest the site of the chancre are found enlarged and indurated in this invasion-period. From the tenth day after the appearance of the primary lesion to the conclusion of the invasion-stage (that is, the date of appearance of the first syphiloderm) these symptoms persist. In general, it may be said that the first half of this period is required for complete evolution of the local adenopathy which in the latter half may be somewhat less conspicuous, but which yet often, at the termination of this stage, exhibits the evidence of pathological activity described above. In some cases the glands become swollen, tumid, and tender at the onset of general symptoms. The induration of the glands may persist afterward for months, the duration of the syphilitic bubo depending somewhat upon the treatment pursued. Suppuration of these indurated glands is very rare. The lymphatic vessels in anatomical connection with such glands may also undergo this specific induration, and be represented by dense quill-sized cords, single or multiple, reaching from the site of the chancre to the single lymphatic gland or cluster of glands which are superficially involved.

Besides this persistent indurated condition of one or several of the glands near the chancre-site, noticeable in the invasion-stage of general syphilis, there is usually appreciable toward its conclusion a remarkable and often suddenly occurring engorgement of the superficial ganglia. This symptom is not of local but of systemic importance. It is related less to the chancre than to the general oncoming syphilis. It is an early and almost constant symptom of general infection, often, as just described, particularly conspicuous prior to the evolution of the first syphiloderm; at other times, not fully developed till such early symptoms have been declared, and in both cases usually persisting for some weeks after its appearance.

Reference is made to a tumid and engorged, very rarely indurated, often softish condition of the chain of lymphatic glands extending along the posterior border of the sterno-cleido-mastoid muscle, or of the post-auricular, suboccipital, epitrochlear, or submaxillary glands. These glands, usually so small as to be scarcely recognizable by the finger passed over the skin, may increase till they are of the size of a bean or a small nut, and are even conspicuous to the eye of the observer. The two glands beneath the occiput are often very significantly enlarged in this way, irrespective of the occurrence of any lesion upon the scalp or vertex. This general engorgement of certain special lymphatic ganglia is often symmetrical, the glands, for example, behind one ear, or over the mastoid process, corresponding in size and firmness to those of the other side of the body. Occasionally this engorgement of glands in special regions of the body is proportioned in extent to the syphilodermata developed in contiguous regions, of the scalp, for example, where the suboccipital ganglia are affected.

(c) *State of the Blood.*—Syphilis, though often popularly described as a "blood disease," is actually one in which but very few alterations can be demonstrated in

the blood; and these but for a relatively brief period of its long course. Grassi, Wilbouchewitch, and Mélassez have by the process of repeatedly counting the number of red blood-corpuscles present in small selected portions of a drop of that fluid, determined that these constituents of the blood were from one-half to one-seventh fewer in number, in certain stages of syphilis, than in the average of sound health. With this proportionate decrease in the number of the red corpuscles, there is a relative increase in the number of the white globules. This change is characteristic of the early stage of syphilis only. It is often especially noticeable just prior to the evolution of the first syphiloderm. If syphilis is ever demonstrated to be caused by a specific bacillus, it will be found doubtless that, in the period under discussion, these micro-organisms are multiplying, and by the avenue of all the vascular channels gaining access to distant parts of the body; even, it may be supposed, to special regions where months later a tertiary gummatous product may form.

(d) *Chloro-anæmia.*—The chloro-anæmia which is the result of systemic intoxication in syphilis occurs from time to time in most well-marked cases of the disease. It may be an early or late symptom, and in grave and so-called galloping cases is throughout a marked feature of the malady. In tertiary and ulcerative types of syphilis, it may depend more upon the local symptoms than upon the general condition, and, in some cases, is without question a resultant of the long-continued inroads of the poison upon the general health.

This chloro-anæmic, anæmic, cachectic, or asthenic state is often conspicuous in the invasion-period now under consideration, with mild or grave symptoms, particularly in persons of a naturally weak constitution, or in those prostrated by other previous disorders. Often, just before the appearance of the earliest syphiloderm, the patient exhibits a pallor of the face, accompanied by a discolored, muddy, leaden, or saffron-like tint of the skin. With this there may be emaciation, weakness, and vague rheumatoid pains in different parts of the body (substernal, plantar, temporal, tibial, etc.). There is anorexia, and the patient will often describe his condition as one of "biliousness." In exceptional cases there is decided icterus, with yellowish conjunctivæ and urine of high specific gravity and heightened color. With this condition may be associated the ganglionic engorgement already described; the characteristic induration of the glands nearest the chancre; and the persistence of the initial sclerosis as a dense ridge, button, plaque, nodule, agglutination of tissue (digital chancre), or thin circumscribed sheet ("parchment" form of induration).

(e) *Syphilitic Fever.*—Recurrent, remittent, more or less persistent, and even intermittent elevations of temperature are of frequent occurrence in syphilitic subjects, more particularly in the early stages of the disease. Greater stress is laid upon this by certain English authors than the subject seems to deserve.

From one week to a fortnight before the first syphiloderm appears, with and without the icteroid, cachectic, or anæmic hue of the skin described above, the bodily temperature may rise to any point from 101° to 105° F., the lower figures representing the average of all cases where any such form is recognized by the physician; the higher, cases characterized by a tolerably profuse first exanthem of syphilis. Usually this is a transitory symptom of the disease; but at times it persists for weeks. In cases, it is preceded by a sensation of chilliness or distinct rigors. When remittent, the exacerbation is usually vespertine. There is commonly coincident thirst, malaise, *courbature*, and osteocopic pains with headache and backache. In some cases, the febrile state is so insignificant as to attract no attention.

SYPHILODERMATA (syphilides, cutaneous lesions of syphilis).—The skin-symptoms of syphilis are numerous, widely different in type and career, and of the highest importance in the diagnosis of the disease. In any given case of syphilis, the greater number of skin-lesions are displayed during the first two years after infection, that is, during the so-called secondary stage of the disease. They, however, occur often in grave forms in the late or tertiary period of syphilis.

General Characteristics of the Syphilodermata.—The skin-lesions of syphilis resemble the skin-lesions of almost every non-syphilitic disorder, yet differ from the latter in certain special features. The study of these differences is essential to the recognition of the identity of the syphilitic exanthem. Their characteristics, generally considered, may be classed as follows: (1) Absence of subjective sensations. For the most part the syphilodermata are not accompanied by pruritus, or sensations of burning, heat, pricking, etc. Notable exceptions to this rule may be found, but it is fairly constant of application, and due to the chronicity of the syphilitic exanthemata, their remarkable tendency to recurrence, and their striking amenability to treatment. (2) Career. They are rarely pyrexic; their course is essentially chronic; they are exceedingly liable to recur; and yet, as distinguished from the lesions of epithelioma and lepra, they are relatively rapid in evolution. They are greatly influenced by treatment, and are hence rarely seen when unmodified; but it is highly probable that all of them have, within variable limits, a cyclical career which would be pursued in most of the cases if no interfering agent modified their evolution. (3) Polymorphism. Multiformity of lesions, that is, the occurrence of multiple lesions of different elementary forms at one time upon the same person, is characteristic of several diseases of the skin, including syphilis. In the latter, papules, tubercles, pustules, ulcers, and maculæ may coexist upon the skin of an infected individual, who thus presents a striking contrast with the psoriatic patient, for example—the skin of the latter being possibly extensively covered with exclusively squamous lesions. (4) Color. The color of a cutaneous exanthem differs not only in different individuals of different color-type (blonde, brunette, African, etc.), but also in the same individual from year to year; *e.g.*, the lupous patch of childhood differs from the same occurring at puberty. This is true of the syphilodermata, whose color exhibits the widest range of differences under different circumstances. Certain combinations, however, of the brown, the purple, and the duller hues of other colors are especially striking when seen in syphilodermata that are typical also in seat and configuration. The so-called characteristic color of the syphilodermata has been compared with that of raw ham and of coffee, shades which, when at all distinct, are highly suggestive. After complete involution of many of the syphilodermata, especially those seated on the lower limbs, the deeper pigmentations, suggesting chocolate, coffee, or ink in color, are often recognized. Most of these deeper tints are gradually and completely removed in the months or years that succeed complete involution of the lesion. (5) Contour. Many syphilitic lesions of the skin have a remarkable tendency to assume, wholly or in part, when grouped, a circular outline. This contour is often preserved when there has been both a grouping of elementary lesions and subsequent metamorphosis or degeneration of the lesions thus grouped. In this way the figure-of-eight, the letter S, the dumb-bell, the kidney, and the horseshoe may be represented in outline by syphilitic papules in groups, ulcers, crusts, and even cicatrices. (6) Site. Any part of the skin of the human body may become the seat of a syphiloderm; and, indeed, the entire surface may be thus invaded, either by simultaneously evolved lesions or by rapid extension from one point to another. Syphilis may, however, affect for long periods of time a single region of the skin exclusively. This region may thus be preferred as the result of local irritation; for example, the palms of the syphilitic handworker; the uncleansed anal region of the syphilitic infant; and the mouth of the syphilitic tobacco-chewer. The so-called "corona veneris" is a group of dull-reddish, scaling papules on the forehead, which are peculiarly significant in male patients where the lining of the hat irritates the brow. (7) Amenability to Treatment. Mercury more particularly, and to a less extent the salts of potash after ingestion, are regarded by many practitioners as tests of the syphilitic character of any exan-

them. There are few eruptions which amend under treatment of this character as readily as do the syphilodermata, but it is an error to conclude that the latter only are thus manageable. The almost infinite variability of the skin-picture in syphilis is largely due to its modification in this way by an appropriate therapy. (8) Characters of individual lesions. The scales of syphilis are rarely lustrous or nacreous; they are commonly small, dirty gray, or darker in color, and rarely very abundant. Syphilitic papules are small or large, but often remarkable for a collarette of dirty, whitish scales surrounding their bases. The crusts of syphilis are apt to be dark-hued, in shades of deep-yellowish, greenish, chocolate, and black, from the tendency of many syphilodermata to ulcerate and the production in such ulcers of the pus and blood from which these colors are chiefly derived. The oyster-shell-like crust of rupia is wellnigh pathognomonic of syphilis. Syphilitic ulcers are prone to exhibit the circular outline, or traces of the reniform, figure-of-eight, letter S, and other shapes named above. The cicatrices left by such ulcers have necessarily a similar contour. They are, for the most part, smooth, supple, soft, and unattached. When recently formed, especially on the lower extremities, they are deeply pigmented in shades of chocolate and black. All, however, in time become white and lustrous, suggesting a thin sheet of mica when the centrifugal decolorization, which each very slowly undergoes, is complete.

The Macular Syphiloderm. (a) *The Macular Syphiloderm due to Hyperæmia.*—This is also termed the erythematous syphilide, syphilitic roseola, and the exanthematous syphilide. It is usually the earliest of the eruptions of secondary syphilis, commonly appearing about forty-five days after the appearance of the chancre. It is developed in the form of symmetrically arranged, roundish, oval-shaped, or irregularly outlined maculæ, from the size of a split-pea to that of a small coin, non-elevated, rosy, reddish-yellow, dusky-red, or salmon-and-red, disappearing under pressure. Often at the outset it most resembles a slight mottling or marbling of the surface, and at times requires for its recognition careful observation on the part of the physician. It is probably more often unnoticed by the patient than any other symptom of syphilis, at times escaping observation entirely. It may be generalized, but is usually most conspicuous on the belly, loins, chest, and back. In well-marked cases the face (brow, temples, chin), back of the neck, and extremities, including the palms and soles, are conspicuously marked with it. It may be accompanied by the syphilitic febrile symptoms already described, substernal and other pains, engorgement of the cervical ganglia, mucous patches of the mouth, and other symptoms peculiar to this period. It may persist for a week and fade; or recur in fresh maculations. As the eruption survives, it is more persistent in color under the pressure of the finger. It is decidedly and promptly amenable to mercury. It is not to be confounded with the exanthematous fevers (the thermometer readily indicating the difference); nor with urticaria and the medicamentous rashes, which are more acute in type and accompanied by well-marked subjective sensations; nor with the yellowish patches of tinea versicolor, where a vegetable parasite is visible under the microscope. None of these affections exhibits the other signs of syphilis present in the person displaying the erythematous syphiloderm. The chief diagnostic danger, however, in this connection lies in ignoring, in certain cases, the special character of this indolent, scarcely appreciable exanthem, which rarely attracts attention by subjective annoyance, rather than in any difficulties in determining, after its discovery, to what special disease it is due.

(b) *The Macular Syphiloderm due to Pigmentation.*—This is also termed by some authors the pigmentary syphilide. It occurs in an irregularly circular, ill-defined reticulum, of brownish or chocolate shaded maculations, the color of which does not fade under the finger. Often there is unusual whiteness about the pigmentations, centrally or peripherally situated, Dr. Fox, of New York, having shown that after the central pigmentation occurs there is a centripetal decolorization with deposit of pigment in excess in the interspaces of the original maculæ. The eruption is common about the neck and shoulders of blond women. The author has seen very perfect illustrations of this condition in concentric circles of large pin-head-sized maculæ, alternating with rings of pigment, in Chinese subjects of syphilis. These lesions are obstinate under treatment, and are by many authors not included among the true exanthemata of the disease. They are rather curious pigment-anomalies, occurring in syphilis as in other diseases influencing the nervous centres.

The Papular Syphiloderm.—The papule is the type of most of the syphilodermata. Many of the others are evolved from it; and it is probable that a large proportion of chancres and most mucous patches, condylomata, tubercles, and similar lesions are essentially papules which have been modified by the accidents of site, moisture, heat, etc. Syphilitic papules are circumscribed elevations of the surface, ranging in size from a millet-seed to a split-pea. They may occur as the earliest cutaneous symptom of the disease in its secondary stage, or be developed from the erythematous syphiloderm described above. They may be small or large, pointed or flat, disseminated or in groups.

The Small Acuminate, Papular Syphiloderm ("syphilitic lichen," miliary papular syphilide).—This eruption appears in the form of pointed, firm, circumscribed papules the size of a pin-head or of a millet-seed, often copiously developed, with or without febrile symptoms, over the belly, chest, arms, back, and extremities. In color they vary from rosy-reddish to mulberry or purplish shades, the hue differing widely in light and dark skins. Often the outer layer of the stratum corneum of the epidermis is slightly separated about the individual papule, which is thus surrounded by a faintly defined collar of scales. Often, also, when irritated they exhibit a minute vesicle, pustule, or scale at the apex. Where numerous, they are usually symmetrical and very closely set together. Brownish-red blotches are apt to follow their involution. The eruption may persist for months, and, with or without relapses, may appear in circular or semicircular groups, a ring of minute papules partly or wholly surrounding a confluent central patch.

The Large Acuminate, Papular Syphiloderm.—The small lesions described above may be, in special localities, developed to lenticular dimensions, retaining the conical apex. They may be seen often on the back, shoulders, and chest as purplish red rather than bright red in color, especially in the coarse skins of male patients. They may develop at the apex minute pustules whose involution leaves a small crust capping such papular lesions. They should not be confounded with iodic acne.

The Small Flat, Papular Syphiloderm.—This eruption is made up of roundish or oval, reddish to deep brownish, distinctly circumscribed and softish papules, from the size of a large pin-head to that of a split-pea, and having a flat surface. They are often seen on the chest, face, buttocks, extremities, palms, and soles, and are frequently found near the mucous outlets, though decidedly less often grouped about the mouth and nose than are other lesions to be described later. They may be few, or developed in a copious exanthem. They may be covered with a thin seborrhœic crust, after whose removal is exhibited one of the characteristic and almost indescribable color-shades peculiar to syphilis, a lucent mixture of red, brown, and purple, suggesting the varnished section of a raw ham. They may be fringed or capped with scanty, dirty-yellowish scales. Bumstead and Taylor describe this eruption as rarely occurring in cachectic subjects with a diphtheroid deposit over the papules, covering thus a granulating or superficially ulcerated surface.

Cicatrices seldom follow its involution under mercurial treatment. It commonly requires a week or ten days for complete development and, though occurring as an early syphiloderm, may relapse in any stage of the secondary period. Circinate forms of grouping, with an unchanged central area of integument, are rather more distinct in relapsing than in early forms of the exanthem. These are readily distinguished from psoriasis by the absence of

the abundant nacreous scales of the latter disease, with a history of clearing, not of a primarily cleared centre.

The Large, Flat, Papular Syphiloderm.—This eruption appears in the form of distinctly circumscribed, vivid or purplish-red, flat or slightly globoid papules, disks, "buttons," or nodosities, from the size of a pea to that of a small coin, many of which distinctly exhibit the quality of color seen in a new copper penny. They may become scaly at the surface or the base, or become granular, moist, and secreting in these situations. They are insensitive, and rarely productive of pruritic sensations. It may be developed as a first or later general syphilitic exanthem, or be evolved from the macular lesions of the erythematous syphilide, or, very conspicuously and commonly, in the middle of the exanthematous period of syphilis, with a primary or relapsing and abundant crop of lesions in some special locality—the face (alæ of nose, forehead, mouth), palms, soles, axillæ, buttocks, and extremities. Upon the forehead these lesions are apt to form the so-called corona veneris, glazed papules of coppery hue, arranged often in a line above the brows. They may develop an elevated rim and sunken centre; may ulcerate, especially in cachectic subjects or in localities subject to unusual moisture or irritation. Rarely gyrate and serpiginous lines of these papules are to be seen in special localities, *e.g.*, about the non-bearded lips and chin, or the axilla, where they may form rings. They are to be distinguished from certain isolated psoriatic patches, circinate in outline, (1) by their color, as distinguished from the more vivid hue of psoriasis; (2) by their scanty dull-hued scales; (3) by the history and concomitant symptoms of syphilis.

Syphilitic papules of all types may undergo any one of the following transformations, whose features may often be recognized at one and the same time in the course of the disease:

(1) The evolution of papules may, as a result of hyperplasia or vegetation, proceed to the production of the larger lesions recognized under various titles—warts, papillomata, condylomata, frambœsioid vegetations, etc. In this way isolated or confluent, softish, warty growths, light or deep reddish in color, freely furnishing a secretion, often of most nauseous odor, may cover large surfaces of the body or a single region only (scalp, anus, genitalia). These may be crusted from desiccation of the puriform mucus which smears them; in other cases ulceration ensues.

(2) The evolution of the papules, as a result of the same processes in special situations, results in the production of broad, flat lesions. These are the results merely of the vegetative process occurring where mucous or cutaneous surfaces are in such close apposition that elevation of the lesion is restricted and lateral expansion only is possible. In this way are produced the true condyloma, and the pinkish, whitish, and softish lesions known as the mucous patch of the skin, the vegetating mucous patch, *plaque muqueuse*, etc. They are well-defined, slightly raised, flattened disks, from the size of a bean to that of a large coin, their whitish color largely due to the muco-purulent secretion with which they are smeared, and which furnishes the characteristic, disgusting odor of these lesions. Heat, moisture, friction, perspiration, and neglect of the bath are the fertile agents in their production in the axillæ, perineum, groins, the inner faces of the thighs, about the vulva, and elsewhere.

(3) Papules may scale at apex or base, and the scaling become so significant a part of the process that the papular character of the lesion is almost disguised. In this way is produced the papulo-squamous syphiloderm. The scales are commonly scanty, desiccated, dirty gray in color, often attached, rarely freely shed from the surface. Beneath them may be seen elevated papules of the so-called copper color, having the smooth, glazed surface of such lesions, or dull-red maculæ. Very rarely, indeed, the surface is granulating.

Palmar and Plantar Syphilodermata.—Syphilitic papules of the palmar and plantar surfaces are peculiar: 1, Because of the unusual thickness of the epidermis of the region affected; 2, because of the intermittent friction, contact, and exposure to which the organs are subjected. They may be early or late, transitory or peculiarly obstinate, and recurrent lesions. Careful inspection of the palms of the majority of patients exhibiting a copious macular exanthem will result in the detection of a few pea-sized discolored blotches in this region, which often cover themselves with a thin, slightly adherent scale. In greater approximation to the type of the average cutaneous papule, firm, circumscribed, dull-reddish, and distinctly elevated lesions, from the size of a large pin-head to that of a pea, are often seen in the same region. A variation from this type produces the dirty-whitish, corneous, epidermal masses embedded in the palms and soles like foreign bodies, and almost as readily separable. These are arrested forms of complete evolution of the syphilitic papule in the palms and soles. When progressing, unmodified by treatment, they become depressed and poorly defined in outline, coalesce so as to form circumscribed patches, from the size of a coin to that of an egg or larger, with newly developed outlying lesions. The next features are unquestionably impressed upon the patch by the traumatisms and stretching of the infiltrated skin. Scaling follows, centrally and at the periphery; fissures form in the lines of the furrows; ulcers develop centrally situated, circular, oval, or stellate in outline. A purplish-floored ulcer is often seen here, its contour suggesting the fracture of a pane of glass. Recurrent and abortive attempts at reproduction of the palmar and plantar epithelium result in the formation of strata of ragged-edged epidermis, which irregularly fringe the deep losses of tissue. The entire palm or sole may be involved, and the process gradually sweep up to the wrist or ankle, and over the digits, affecting also the nails. The dorsal surfaces are occasionally involved, but always by extension from the palms or soles. Psoriasis limited to the palms and soles is of exceedingly rare occurrence; the specific lesions of this region are far more common, and are often accompanied by other unmistakable signs of syphilis with a history of infection. Squamous eczema is at times limited to the palms and soles, but, in the vast majority of all cases, affects the entire region, including the palmar faces of the digits, and is accompanied by itching.

The Pustular Syphiloderm.—Pustules occur as early and late manifestations of syphilis, being, however, less frequently observed than the lesions just described. They are of the size of a pin-head to that of a bean, transitory or persistent, with mild or grave symptoms, and may originate as macules or papules, be isolated or grouped, scanty or abundant, and result in crusting, ulceration, and cicatrization. "Papulo-pustular," "pustulo-crustaceous," and similar terms are employed to indicate these mixed forms. Authors have also employed the phrases, "acne-form," "variola-form," "impetigo-form," "ecthyma-form," etc., to designate the several varieties of the pustular syphilodermata. These terms are here purposely omitted, for the reason that the several diseases whose names are selected for comparative purposes are represented by lesions widely varying in the different stages of each disease, and exhibiting different features in different individuals. The phrases "syphilitic psoriasis," "syphilitic eczema," etc., are similarly discarded, as tending to contribute to the same confusion in the mind of the practitioner and student.

The Small, Acuminate, Pustular Syphiloderm.—These are of the size of a pin-head and larger, vivid or dull-red, roundish, rapidly or slowly formed, and superficially seated, isolated, or well-nigh confluent pustules, which may be copiously developed in a general exanthem with syphilitic fever, or, more commonly, recognized in clusters about the regions where the pilo-sebaceous follicles are large and abundant. They may begin as macules or papules. The apex of each becomes yellowish green as the pus forms, which may desiccate into minute crusts or may cover underlying ulcers of similar size. They may assume at times the circinate outlines. They are often seen on the scalp, face, neck, and trunk; rather less frequently on the extremities. Involution is often followed

by rather persistent pigmentations; more rarely by minute atrophic scars.

The Large, Acuminate, Pustular Syphiloderm.—Yellowish-brown, conical pustules, of the size of a pea and larger, may develop slowly from the small lesions just described, or rapidly from maculo-papules. They are usually superficial in situation, become crusted at the apex, and, after the formation of the crust, may be depressed centrally. Ulcers frequently form as the result of this process, whose healing may leave small cicatrices. They form over the scalp, face, neck, shoulders, and extremities; and are usually the expression of either a graver form of syphilis or of a syphilis less judiciously managed than the lesions previously described.

The Small, Flat, Pustular Syphiloderm.—This is a relatively frequent manifestation of syphilis, beginning by the development of circumscribed macules or maculo-papules, which rapidly form flat, roundish pustules, the size of a pin-head and larger, and superficial in situation. They are usually grouped, isolated, and at first not confluent; but their reddish and purplish areolæ become fused, and the whole is soon covered with a flattened, dirty-yellowish, and greenish crust, which commonly surpasses the limits of the patch. On the removal of the latter, a violaceous surface is seen, granulating, puriform, occasionally superficially eroded, possibly ulcerated. These lesions are often seen in and about the scalp, and about the lips, chin, beard, and trunk. In persons of weak constitution, and not properly treated, the face will occasionally be found almost completely covered by an irregularly crusted mask, formed in the manner described above, the pustulo-crustaceous lesions occasionally spreading in a serpiginous course, or forming the familiar rings, or segments of rings, seen in the grouped syphilodermata.

The Large, Flat, Pustular Syphiloderm.—Pustules, the size of a bean and larger, deeply seated, or projected from the surface, may represent any of the forms described above, proceeding to full evolution, usually in cachectic subjects. They represent, also, the later periods of the so-called secondary stage of syphilis. Often they have dark-red, deep, infiltrated bases with violaceous areolæ; and the pus finally desiccates into thick, bulky, greenish, or blackish crusts, firmly adherent to the edges of a foul-based, hæmorrhagic, or pus-filled chamber beneath; or, after bursting, they leave open, sharply cut ulcers, with blood or pus freely formed from an exposed, eroded, sloughing surface. The ulcerative phase, with its crust, is, indeed, often the conspicuous feature of the process, the deep-seated pustular lesion which ushered in the mischief being thus speedily metamorphosed. These ulcers may be few or numerous, superficial or deep; and may be in outline circular, oval, semicircular, dumb-bell-shaped, etc. Their cicatrization commonly results in a typical syphilitic cicatrix.

Rupia.—This term was at one time employed as the name of a distinct disease. It has long since lost any applicability to non-syphilitic disorders. Every rupia should to-day be recognized as syphilitic. Indeed, according to modern usage, the name merely describes certain peculiarities in the syphilitic crust. The explanation of its former temporary and unmerited elevation to the dignity of a disease supposed to have a separate entity, is to be found in the fact that occasionally a patient will be extensively covered with rupioid crusts, who exhibits no other symptom of syphilis.

The crusts thus named may be few and small, or large and generalized. First appear macules, then pustules, whose contents desiccate into crusts of greenish, brownish, and blackish shades, covering and nicely fitted over underlying ulcers. The ulcer slowly spreads at the periphery, and its purulent and hæmorrhagic secretions add by desiccation to the bulk of the crust. The additions are made beneath and laterally to the under surface and edges of the closely adjusted crust, which hence becomes a conical, stratified shell, usually with a slightly concave inferior surface, the whole often compared to an oyster-shell. Each succeeding stratum of incrustation, from the conical apex of the crust to its base, represents, therefore, a somewhat larger ulcer and a somewhat more abundant secretion. There may be an outlying violaceous areola. The indolently spreading ulcers beneath correspond in size to the shells which cap them. They may be superficial or deep, but usually have a foul, purulent, or hæmorrhagic floor, and punched-out edges. Grave as is the condition of the patient who is extensively covered with the largest-sized rupioid lesions, the best of results may be anticipated under proper hygienic management and energetic treatment.

The Vesicular Syphiloderm.—Vesicles are rarely the results of the syphilitic process in the skin. They usually point to an exudation more acute in type than that recognized in the indolently traversed cycle of syphilis. Occasionally miliary papules exhibit a vesicular apex containing a droplet of serum. Circinate and other groups of vesicles are described by French writers as of occurrence in this disease. Two explanations of the so-called vesicular lesions are at hand: first, the development of eczema, herpes, etc., in infected persons—phenomena not rarely observed by an expert; second, the occurrence of vesicular lesions provoked by externally applied or internally ingested medicaments employed for the relief of the systemic disorder.

The Bullous Syphiloderm.—Discrete, roundish bullæ, from the size of a pea to that of a small egg, appear simultaneously or in crops upon the syphilitic skin, in consequence of a more or less circumscribed elevation of some portion of the epidermis by accumulation of a clear lactescent serum, pus, or blood. The contents usually desiccate into bulky, adhesive, stratified, greenish or dark-colored crusts, which may cover granular, eroded, or ulcerative surfaces. Often they are surrounded by a violaceous halo. The ulcer, after removal of the crust, may spread in depth or area, or cicatrize; this according to the vigor of the patient and the treatment pursued. Lesions of this sort are rather more often recognized upon the extremities than elsewhere, in consequence of the greater distance of the latter from the centres of circulation. They are more often encountered in late periods of secondary or tertiary disease, and in cachectic subjects. They are for these reasons most often seen in the tender skin of the infant who is the victim of hereditary syphilis.

It should never be forgotten, when making a diagnosis of the bullous syphiloderm, that the iodide of potassium, in exceptional cases, is capable of producing such lesions in typical aspect when administered to the syphilitic as well as to the non-infected patient. American observers chiefly have called attention to this important fact, among them Drs. O'Reilly, Graham, Morrow, and the author.

The Tubercular Syphiloderm.—Hyperplastic evolution of the papule, besides producing the aberrations from type already described, may also result in the formation of definitely circumscribed, deeply seated, single or multiple, bright-reddish or livid, solid, cutaneous, or more commonly subcutaneous, lesions, from the size of a pea to that of a small egg, known as tubercles. These are usually late secondary, or early or late tertiary syphilitic symptoms, which, in consequence of difference of involution, are divided into two classes.

The *resolutive tubercular syphilide* is characterized by: Slow evolution without marked subjective symptoms, disappearance after absorption of the plastic infiltration commonly involving the entire thickness of the derma, and the production, without previous ulceration, of an indelible scar. The lesions begin as superficial, reddish, and roundish gummatous nodules, the size of a pin-head, which, as they attain the larger dimensions named above, become flatter, smoother, more lustrous, and more deeply tinted. They are largely facial or cervical in situation, but may also spread over the trunk and extremities. They are often free from scales, except when seated upon the palms or soles, in which situations they may be covered with thick corneous plates beyond whose borders can be recognized a violaceous halo. These lesions may be generally disseminated, or grouped in distinctly circumscribed patches, either circular in outline or exhibiting some modification of the latter (*e.g.*, the reniform, horse-

PLATE XXIX.

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TUBERCULAR SYPHILIDE.

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uously smaller size of the scar-like depressions, usually furnish a clew to the distinction sought to be established.

THE GUMMATOUS SYPHILODERM.—Single and multiple, isolated or massed nodules, from the size of a pea to that of an egg, or larger, originating simultaneously, but commonly invading the skin as they develop, occur in late, rarely in early, periods of syphilis, and are termed gummata in consequence of the gummy material they furnish when disintegrating. They are rarely numerous, often not more than from two to six affecting a single patient. As an exceptional fact, hundreds may be seen covering different regions of the body. They are peculiar to syphilis; in other words, they do not pursue, in the course of other affections, the same classical cycle of evolution and involution. Yet they are really syphilitic tumors, allied, on the one hand, to the hyperplastic process which produces the papule and tubercle; and, on the other, to the histological type of tumors in general. Pathologists have some ground for believing that the so-called gummous material of this lesion is to be recognized in the nodules that glue the iris to the capsule of the lens, and even in the neoplasm that constitutes the mass of the initial sclerosis.

After development, gummata may for a long period of time be perceptible beneath the skin as smooth, circumscribed, insensitive, firm nodules, undergoing no change. Later, they become slightly painful; there is passive hyperæmia of the overlying skin; attachment between the skin and the tumor is effected; then follow, usually, fluctuation and evacuation (spontaneously or by surgical interference) of inspissated blood and pus, or of the contents of a true, circumscribed abscess. The gummatous mass constituting the tissue, bathed in pus and blood, is slowly or rapidly removed by this process, in the course of which is formed the gummatous ulcer. This has the circular outline, precipitous edge, sloughy floor, foul secretion, livid halo, and phagedenic tendencies already described as characteristic of the syphilitic ulcer in general, with this special added feature, that it is particularly deep. Its floor rests on subcutaneous tissues. It involves fasciæ, periosteum, muscles, large vessels, bursæ, nerves, bones, tendons, and other important tissues. Its walls, carefully inspected, often exhibit the sharp and resisting edge of a dense aponeurosis, the glistening white border of a tendon, or the firm periosteum sheathing an osseous plate.

Occasionally gummata are lodged in, rather than beneath, the skin, the firm, movable mass being then readily defined by palpation. Whether superficial or deep in situation, they may undergo complete resolution. When disintegrating by ulceration, they may go on to produce those extensive and formidable losses of tissue, complicated with erysipelas, pyæmia, etc., in the subjects of cachexia and alcoholism, which make syphilis, in some of its manifestations, a veritable scourge. Though occasionally numerous, not more than from six to eight are usually to be recognized in the person of a single patient. They are most frequently developed upon the lateral surfaces of the legs, and, next, proportionally after these, over other parts of the extremities, the face, scrotum, buttocks, neck, and the breasts of women. The importance of their recognition in the last-named situation, when the question of cancerous and other malignant tumors of this organ is presented for consideration, can scarcely be overestimated. The author has seen a gumma, the size of a turkey's egg, in the breast undergo complete involution under specific medication only.

The elephantiasic aspect of the face and legs of certain patients who are afflicted with extensive gummatous tumors and infiltrations of the cutaneous and subcutaneous tissue is a matter of great moment for the diagnostician. In almost every community there is some such patient, with a striking deformity, the nature of whose malady has been altogether unknown for years. In such cases there is often an obscure history, which, perhaps, the expert alone has been able to correctly interpret. The patient has been supposed to be the victim of "elephantiasis." The nose, lips, cheeks, and chin are possibly densely thickened, distorted, empurpled, and irregularly ridged and seamed with nodules, scars, and ulcers; or the leg is in the pachydermatous condition seen in the "Madura foot" and other diseases. It is a large, unwieldy organ, ridged, of cartilaginous hardness, furrowed, and covered with an integument looking like the bark of a tree. Careful inspection, however, always reveals in this mass the typical cicatrices of ancient gummatous ulcers, and the traces of new and old nodules buried in the hypertrophied and œdematous mass. Here, as in so many other of its formidable aspects, syphilis reveals its amenability to proper management. The changes that can be wrought by treatment in these apparently desperate cases are in the highest degree satisfactory.

THE SERPIGINOUS SYPHILODERM.—Though not distinguished by the name of an elementary lesion whose preponderance might justify such a position, this syphiloderm has an individuality requiring its separate consideration.

In its superficial forms it is preceded by the appearance of small, pointed or flat syphilitic pustules, which form a circular or partially circular group of lesions in disks of the size of an egg and larger. These disks are soon covered with a yellowish, greenish, or blackish crust, which gradually clears from the centre, leaving there a granulating or smooth, reddish or normally tinted, atrophic or only superficially altered integument, surrounded by an entire or broken ring of attached crusts, beyond which is a livid halo. Underneath this latter is a superficial, centrifugally spreading ulcer, uniformly annular in contour, or here and there broken by bridges and islands of unaltered skin. Often this annular ulcer is seen to be composed of roundish excavations, the size of a pea and larger, arranged circle-wise, with confluent crusts. In other cases the crust is scarcely more than a narrow ring, no broader than the smallest penknife-blade, which, as it spreads centrifugally, leaves cutaneous areas of former invasion, the size of the palm and larger, pinkish-red or slightly pigmented in color, at times decidedly cicatriform, at other times texturally unaltered. In this way an entire buttock or limb, or the face, may be progressively involved.

The deep serpiginous syphiloderm always spreads, as Bumstead and Taylor have well indicated, from a gumma or other late lesion of syphilis. A deep ulcer results, which attacks the subcutaneous tissues. The centre is soon represented by a tender or firm scar; the advancing edge by a thick, greenish or blackish, adherent crust, covering a deeply cut circular exulceration with punched-out walls and foul secretion. The dull, purplish areola of all similar lesions is visible at the periphery beyond its advancing edge. Its progress over the skin is decidedly more serpiginous than in the direction of the radii of a circle. Here and there a kidney-shaped, or horseshoe-shaped edge exhibits a deeper excavation, or a more tenacious, bulkier, and darker crust. In yet another part of the same disk the ring may be represented by a partially cicatrized border, or a wide bridge of unaffected skin. This is a late, exceedingly obstinate, and intractable form of syphilis, leaving generally a deforming scar. It is to be distinguished from lupus (which is more often seen on the face) by its definite outline, its deep pustular, rather than nodular, elementary lesions, its sharply cut ulcerations, but, above all, by its relatively rapid progress.

MALIGNANT SYPHILODERMATA.—Syphilitic cutaneous and subcutaneous lesions are at times malignant in type, and then commonly precocious in occurrence and acute in course. They are described by Bazin and other French authors as "malignant precocious syphilides." The intensity and violence of the symptoms in these cases is in general due to the occurrence of the disease in cachectic subjects, those who are debilitated by age or previous or concurrent diseases, those deprived of the essentials of healthy living, viz., wholesome food and drink, hygienic environments, freedom from mental anxiety, and a proper adjustment of labor to bodily vigor.

In patients of this class the chancre is scarcely cicatrized before so-called tertiary lesions appear. They are

divided by most authorities into (*a*) the puro-vesicular syphiloderm; (*b*) the tuberculo-ulcerative syphiloderm; (*c*) the gangrenous tuberculo-ulcerative syphiloderm. These names are mainly groups of symptom-phrases, the lesions themselves exhibiting a wide variation indicated by both mild and grave characters.

The milder forms are really precocious, rupioid lesions following isolated or grouped pustules, which are rapidly followed by ulcers, thickly covered with laminated crusts. In a more accentuated form the malignity of the outbreak is indicated by the development of lenticular tubercles, which hasten to break down into ulcers of characteristic syphilitic edge, secretion, floor, base, and areola, which attack the face, trunk, hands, or extremities. The graver forms are precocious, tubercular, ulcerative, and gangrenous. A group of nodules in or beneath the skin surrounds itself with significant purpuric points, supposed to indicate an endarteritis of the peripheral vascular elements. The whole rapidly or slowly becomes gangrenous, showing a dry, blackish eschar, which spreads at the periphery, and insidiously, as it encroaches upon the sound tissues in the vicinity. Sometimes a line of demarcation is formed, not between the gangrenous mass and the sound skin, but between the former and a thickened empurpled zone which surrounds it. When the slough is removed, a conical crateriform ulcer is exposed, having a fœtid secretion, a sloughy floor, and markedly everted edges. The destructive process may progress till fatal results are produced, the patient succumbing to fever or marasmus and adynamia. But this is rare. Under the best treatment repair sets in, granulation is followed by cicatrization, and there is apparently complete restoration of the general health.

Cutaneous lesions and symptoms other than the forms described above are neither numerous nor important, but have been described by authors. Dr. E. B. Bronson, of New York, has described an erythanthema syphiliticum in which vesico-pustular and other lesions were grouped upon an erythematous base. Hæmorrhagic effusions within the skin occur chiefly in patients who are the subjects of hæmophilia, and who have also contracted syphilis; in children afflicted with hereditary syphilis; in patients with paraplegia resulting from syphilitic involvement of the cord (purpura of the lower extremities); and as an accident of a number of secondary and tertiary lesions. The author has seen two such cases occurring in syphilitic disease of the cord. It should never be forgotten that the iodide of potassium, when administered for the relief of syphilis, may produce purpuric spots, especially over the lower extremities.

Lastly, eczema, psoriasis, the animal and vegetable parasitic affections of the skin, pruritus, and the various dermatides, all the forms of acne due to the ingestion of the iodic compounds, and other cutaneous disorders affect the syphilitic as well as the non-syphilitic patient. Each of them exhibits its special peculiarities, apparently not at all or very slightly modified by the syphilitic diathesis, and is recognized in its identity as distinct from the manifestations of syphilis without great difficulty on the part of the diagnostician. This recognition is a matter often of the highest moment, as the anxiety and dread occasioned in many patients by the discovery of these intercurrent affections (to which the mass of mankind is subject) are out of all proportion to the real import of the symptoms presented in such cases.

TREATMENT OF THE SYPHILODERMATA.—The internal treatment of the syphilodermata is that of syphilis in general, including the use of mercury, the iodide and other salts of potassium, iron, cod-liver oil, and a nutritive regimen.

Many of the lesions, however, require local treatment. The salves which are most effectively used with this end in view contain one of the salts of mercury. Among these may be named the ammonio-chloride, in the strength of from five grains to half a drachm to the ounce (0.33–2.0 to 32.00); the red oxide, in the strength of from five to ten grains (0.33–0.66) to the same quantity; the ten or twenty per cent. oleate of mercury; the mild chloride, in the strength of from ten to thirty grains (0.66–2.0); mercurial ointment, in the strength of from half a drachm to a drachm (2.0–4.0) to the ounce; and the ointment of the nitrate of mercury in nearly the same strength. The bases of these salves may be vaseline, cold cream, lanoline (Liebreich's wool-fat), or simple cerate, a drachm (4.0) or more of glycerine being added to the ounce (32.0) of each when requisite to produce softness in the mass. Vaseline is preferably employed as a basis for salves to be applied over the scalp and hairy parts.

Besides the mercurials the tars are employed with advantage, including the oleum cadini and the oleum rusci (rectified or crude), in the strength of from half a drachm to a drachm to the ounce (2.0–4.0 to 32.0) of basis, adding an equal quantity of finely levigated prepared chalk to obtund the sharpness of the tar. These are excellent applications to palmar and plantar syphilodermata, when preceded by maceration of the affected surfaces for several minutes in water as hot as can be tolerated. Often the thick epidermal scales of these regions are best removed at the time of these macerations by the aid of a shampoo prepared by adding an ounce of glycerine to two or more ounces of the tinctura saponis viridis of the Pharmacopœia. After the shampooing with hot water, the hands or feet are dried, the salve well rubbed in, and gloves are drawn over the hands, or stockings over the feet. Other ingredients are often incorporated with such salves with excellent effect. Among them may be named salicylic acid, ten to twenty grains to the ounce (0.66–1.33 to 32.0); chrysarobin, pyrogallol, and ichthyol, in the same strength; zinc oxide and the subnitrate of bismuth, half a drachm to a drachm to the ounce (2.0–4.0 to 32.0); and the oleate of lead, in the form best known as Hebra's unguentum diachyli albi.

Powders occupy a most important place in the local management of the syphilodermata, more particularly those that are ulcerative in type. Among them may be named iodoform, hydronaphthol (1 part to 50 of fuller's-earth), and iodol, boric and salicylic acids, calomel, starch, camphor, and lycopodium. Many of these are advantageously employed over such moist lesions as condylomata after they have been washed in a lotion of chlorinated soda or carbolic acid, so as to be not only deprived of their usual disgusting odor but thoroughly cleansed.

Lotions of the kind just suggested are useful in the management of a number of the secreting syphilodermata. Others are compounded with the corrosive sublimate, one-half to one grain to the ounce (0.33–0.66 to 32.0) of bay-rum, Cologne-water, or the rectified spirit of wine. Lotions containing tar, salicylic acid, carbolic acid, and boric acid (often in saturated solution) meet the indications of many cases.

For the purpose of stimulating or otherwise dressing mucous patches and indolent ulcers, solutions of the nitrate of silver, five grains to a drachm to the ounce (0.33–4.0 to 32.0), or crayons of the solid salt may be used; or even the strong caustic solutions, *e.g.*, of the hydrate of potassium twenty to sixty grains to the ounce (1.33–4.0 to 32.0), or of nitric acid. Solutions of corrosive sublimate in tincture of benzoin, or of myrrh, one to two grains to the ounce (.066–.033 to 32.0); benzol, creasote, and solutions of the permanganate of potassium and resorcin, one to five per cent., are also useful in many cases; the first two for destructive effects, the last as antiseptic dressings.

The principles on which should be based the local treatment of the syphilodermata are those recognized in all similar non-specific affections of the skin. Of chief importance is the treatment of the disease itself, whether by internal medication, inunction, fumigation, or hypodermatic injection. To this, in most cases, may be added the local treatment with marked advantage. The scalp, hands, and feet may be often shampooed, and subsequently dressed with a salve or lotion. Pustules are to be opened, crusts removed, and small or large ulcerated surfaces cleansed, cauterized or stimulated, and antiseptically dressed. Soap and water are as imperatively required for the syphilitic as for the non-syphilitic skin.

Frequent applications of water as hot as can be tolerated are often required for the relief of pain, and the surgeon's knife is needed for opening softened gummata. In extensive syphilitic ulcerations an exceedingly valuable resource is the use of the continuous hot-water bath as employed in Vienna, the patient, if his ulcers can be in this way immersed in the water, remaining in it for hours, the bath being kept as hot as is grateful to the surface of the immersed skin. The bath is left only on occasions requiring evacuation of the contents of the bladder or of the rectum, or in order to secure sleep. Lastly, the mercurial, rubber, lead, and other surgical plasters, borated cotton, antiseptic wool (medicated with the mercuric iodide), prepared oakum, fuller's-earth, and the other articles needed to make the dressings of modern surgery, are never more useful than in the management of multiple or extensive syphilitic ulcers.

Affections of the Hair, Hair-follicles, and Hairy Regions of the Skin.—A common manifestation of syphilis is a loss of hair, in excess of the physiological defluvium capillitii, resulting in alopecia. This may be an early or late symptom, rapidly or slowly occurring, scarcely perceptible or greatly deforming, and transitory or resulting in permanent baldness.

The earliest form of alopecia may occur without local subjective or objective sensations, the symptoms being often limited to the loss of hair. It may again be accompanied by macular, pustular, papular, ulcerative, or crusted lesions of the regions affected. It may appear as early as the date of the first syphiloderm, and, indeed, may be the first significant feature of general syphilis. In other cases it is conspicuous only after the third or later month of infection. It may affect any hairy region of the body, but is more commonly noticed on the scalp, beard, mustache, eyebrows, and lashes. Upon the scalp, it is probably much more common of occurrence than of observation, since it is often first recognized in men only after the hair is cut short.

The hair may appear to be merely thinned in syphilitic alopecia, when the pilary loss is actually conformed to type. The close-shaven head of the syphilitic, affected with the early form of alopecia, presents almost always the same appearance. The scalp is then seen to be covered with irregularly circular areas of baldness, symmetrically arranged as regards the two halves of the body, these areas varying in size from a split-pea to a silver dollar. There is asymmetry, however, in the disposition of individual patches. The scalp thus affected may be apparently sound, or dry and lustreless, or, as described above, the seat of a syphilitic exanthem. When the hair is long, as in women, the striking disfigurement visible on the shaven scalp is scarcely apparent; in men whose hair has been cut moderately short the effect is that of a characteristic patchy irregularity, in which it is clear that the temple and occiput are as much affected as the vertex. The eyebrows, eyelashes, and mustache may be merely thinned, or suffer a loss in patches. The shaven beard may present an appearance nowise distinguishable from the condition of the same region when affected with alopecia areata.

The late forms of syphilitic alopecia are always due to destructive lesions of the cutaneous region covered with hairs; and the alopecia is hence usually the less important feature of the disease. Thus deep pustular, gummatous, ulcerative, and other like changes in the scalp are usually followed by an asymmetrical loss of hair, often limited to a single patch, where, after cicatrization, the resulting alopecia is remediless.

The early form of alopecia is unquestionably chiefly due to defective nutrition of the hairs in the hair-follicles, and, as alopecia areata is probably due to the same immediate cause (the remote cause being essentially different), it follows that the shaven scalp presents almost the same appearance in two selected cases of the two diseases. The bulbs of the fallen hairs are seen under the microscope to be distorted and misshapen in early syphilitic alopecia, and the hairs themselves are usually dry and lustreless. The pathology of the late forms of alopecia in syphilis is that of the syphilitic process to be studied in the tissues generally. Usually a degenerating gummatous infiltration eventually encroaches upon and destroys the hair-follicle. Syphilitic alopecia is to be distinguished from all physiological losses of hair by its sudden occurrence in persons of the age in which syphilis is most commonly encountered, its asymmetry, and its involvement of the temples and occiput equally with the vertex. A history of infection can usually be obtained, and other symptoms can often be discovered. Seborrhœa capitis, or alopecia furfuracea, is distinguished by its fatty or dry scales, and its failure to remove the hairs in distinct areas. The patches of alopecia areata strongly resemble those of early syphilitic baldness in the shaven head; the loss, however, in the former disease is more sudden, and recovery is marked by the appearance of whitish or grayish downy hairs, which is not often the case in restoration after syphilitic alopecia. The internal treatment is largely that of the secondary symptoms of the disease. The local treatment should consist of daily shampooings with hot water and the Sarg fluid soap; or, where mere stimulation is required, by the aid of the tincture of green soap flavored with lavender. After such shampooing the scalp may be anointed with scented lanoline or vaseline, or with an oleaginous lotion made by adding two drachms each of the oil of sweet almonds and glycerine to an ounce each of the spirit of rosemary and alcohol, and two ounces of Cologne-water.

Affections of the Nails, Matrix and Bed of the Nails, and Adjacent Parts.—The term onychia is applied to the changes which are first apparent in the nail; and paronychia to those which only secondarily affect the nail and primarily the matrix, nail-bed, or cutaneous folds by which the nail-substance is surrounded. It is probable that the distinction is purely artificial, both forms being preceded by alterations of tissue exterior to the nail-substance proper. These appendages of the skin are frequently affected in syphilis, both during the secondary and during the tertiary stages, and the resulting lesions may be transitory or persistent, and mild or grave in character. The course of these changes is usually chronic.

In the most frequent form of onychia (*onyxis craquelée*—dry or friable form) a portion or the whole of one or several of the nails may become dry, lustreless, grayish yellow in color, friable, rugous, irregularly thickened, traversed by furrows in one or more directions, or singularly disfigured by numerous minute pockets, from which the crumbling nail-substance has fallen or been removed by washing and scrubbing. The nails are usually tilted up at the free border and separated from their beds. Careful examination will often reveal a ridge of thickened epidermis at the sides or attached border of the nail, which may be normal in appearance or dull purplish in color and scaling; or, on pressure, a few drops of thin, ill-conditioned pus may escape from beneath it. This form is said to be more common in women. Under treatment these phenomena may disappear; and the distorted nail be pushed forward and replaced by a healthy new one. In other cases one or several of the nails are insidiously loosened from bed and matrix, and are shed without the occurrence of any appreciable change in the surrounding parts, precisely as the hairs fall in many cases of syphilitic alopecia. Sometimes, even when attached at its border, the nail is seen to be completely separated over its entire area from the bed beneath. When the nail, on the other hand, is affected with an onychauxis, it may increase to three or four times its normal bulk, a condition described by some writers as hypertrophic onychia.

Paronychia may affect the whole or a part of the nail, and be dry or ulcerative in type. In the former case a dull-purplish ridge of cutaneous tissue, in the vicinity of the nail-fold and including it, becomes indolently thickened, scaling, and fissured. Superficial ulceration may follow, with purulent or hæmorrhagic secretion and crust-formation, the ulcer spreading slightly beneath the nail at one point, the substance of that organ having already exhibited the changes due to impaired innervation. The characteristic feature of this complication is a finger with its distal phalanx having a bulbous appearance, its par-

tially altered, dirty-looking nail tilted upward or to one side, and a dry, scaling, or indolently granulating surface exhibited in the exposed part of the bed.

Ulcerative paronychia is characterized by a shallow or deep ulceration extending at the central or lateral parts of the nail-fold, matrix, or bed, bathed with a sanguinolent, thin, or ill-conditioned pus. It may begin with the dry lesions described above, or with the development of marginally seated papules or pustules. The nail may, as a result, be in lateral deviation from the axis of the phalanx, or partially or wholly loosened from its attachments. In this state it may present any of the changes seen in syphilitic onychia. The nail-bed, when thus exposed, is usually tumid, covered with a thin, puriform secretion, granulating, or the seat of an irregular, firm, and whitish, epithelial investment. Thin layers of new nail-substance speedily form over this surface if proper treatment be instituted; and, even in the cases where a distorted nail at first covers the bulbous phalanx and its purplish, tumid nail-fold, the restoration is eventually complete. In some cases the ulcer first forms beneath a crust under the free edge of the nail, and thence, when not properly managed, spreads irregularly over the matrix, the nail becoming loose and undergoing the changes already described. Care should be taken in the diagnosis of such cases to exclude trichophytosis unguium (where the parasite is recognizable under the microscope); eczema and psoriasis (in which there is no history of syphilis and none of its other symptoms); digital chancres (in which the nails are not chiefly involved); and ordinary forms of paronychia (which commonly spare the nail-bed and matrix).

The treatment is largely internal; locally the white precipitate salve [one scruple to the ounce (1.30 to 32.0)] may be applied on rags. Ulcers may be dressed with pencillings of the nitrate of silver, followed with iodoform or iodol in powder.

Affections of the Eyes.—The *bones* composing the orbit may be involved in osteitis or periosteitis, with degenerative results in the form of caries or necrosis. In this way may be lighted up an intraorbital cellulitis resulting in abscess. Nodes also occur within the orbit, and may be followed by serious consequences when productive of pressure-effects. The lachrymal passages also may be involved in obscure catarrhal changes, associated with pharyngeal lesions. Mucous and subcutaneous tissue, periosteum, and bone may be eventually implicated, with the result of producing lachrymation, epiphora, abscess, and eventually fistulæ. The treatment is by division of the canaliculi and dilatation of the canal by probes. The parts may then be treated with weak injections of the nitrate of silver, or, what is fully as valuable, two to five per cent. solutions of resorcine. When the canal is pervious to the probe, the trouble is usually due to changes in the periosteum of the nasal process of the superior maxillary bone. The frequent application of water, as hot as can be borne, to the affected parts, if required in connection with the application of fomentations, will often give relief in these cases when energetic constitutional measures are adopted. Bumstead and Taylor report syphilitic changes in the lachrymal gland sufficient to produce a species of ptosis, and also gummata of the caruncles.

The *eyelids* may be severely and extensively involved in syphilis. They may be the seat of papules, pustules, ulcers, and resulting cicatrices dragging the lids into ectropion. Syphilitic ulcerations attack the canthi and free edges of the lids, encroaching also upon the mucous surfaces. The author has seen both upper lids symmetrically involved in ragged ulcerations of the edge resembling the work of a punch. Degenerating gummata of these regions often leave disfiguring cicatrices. The palpebral conjunctiva is often the seat of mucous patches. Subcutaneous indolent nodules, the size of a hemp-seed to that of a pea, occasionally form in the lid, which may obstinately persist when treated. The tarsus is reported also by several observers to have been involved in a tarsitis syphilitica, which is at first productive of tumefaction of the lids, and later, of changes in the cartilage itself. The fasciæ and tendons of the ocular muscles are also liable to syphilitic changes, which may result in thickening, in abscess, or in fistula. All lesions of the eyelids, of secondary and tertiary type, are to be distinguished from chancres of the lid, accidents not of very rare occurrence in the large cities. In these cases there is great tumefaction, brawny, empurpled thickening (of the inner canthus usually, the part most apt to be rubbed by the finger that transports the infective secretion), and a specific induration of the pre-auricular or submaxillary gland—far more commonly the former.

The *conjunctiva* may be the seat of mucous patches, circumscribed macules, papules, tubercles, and gummata. These are, however, rare. The ocular conjunctiva is spared most of the lesions of syphilis, save when it becomes engorged with blood as a consequence of iritis.

The *cornea*, when participating in syphilitic changes, is usually recognized in the victim of inherited disease. There is found, first, slight pericorneal vascularization, in the diffuse form, with one or several centrally situated or marginal opalescent points showing in the cornea. These increase till the whole or a great part of the cornea is involved, producing thus a characteristic opacity limited to the field of the keratitis. With the keratitis of inherited syphilis are often seen the alterations in the color, size, and shape of the permanent incisor teeth, first ably described by Mr. Jonathan Hutchinson. This observer regards the permanent upper central incisors as the test-teeth. These are usually vertically and transversely shortened and thinned, with a crescentic notch at the free border, its convexity regarding the root of the tooth. This notching, most conspicuous in childhood, becomes partially obliterated by attrition in later life. The teeth are also often convergent, occasionally separated; in other cases "pegged," and again discolored in shades of a dull brown.

The punctate form of keratitis is seen both in acquired and late inherited syphilis. Intracorneal puncta, the size of a pin-head, are then visible, careful observation of which reveals the lack of lustre or grayish shade of color of corneal opacities in general.

The *sclera* may be involved (1) in an episcleritis beginning with pericorneal hyperæmic maculæ of a dull-reddish hue, with few if any subjective sensations. A circumscribed portion of the sclera may then appear thickened, and in some cases radii of engorged conjunctival vessels indicate an extension of the hyperæmia to the overlying membrane. In extreme cases the cornea, sclera, iris, and lens are involved in a common inflammatory process; cases which the writer believes originate for the most part in an iritis. (2) An interstitial, or parenchymatous, scleritis may present the features of an inflammation of the organ, or of a gummatous deposit, or of infiltration within its substance, which, following the rule in similar involvement of other organs, may undergo resolution, or degenerate into an ulcer with irregular edges, and softish, grayish floor. When the cornea also is implicated, one sees a characteristic conical area of corneal opacity, its base resting upon the involved sclera, its apex projected forward to the centre of the cornea.

Iritis.—More than one-half of all cases of iritis are of syphilitic origin, the proportion ranging between sixty and eighty per cent. of all cases. It is not only a common complication of the disease, but, as regards the loss of vision, one of the most disastrous. The symptoms of specific and non-specific inflammation of the iris are, taken *per se*, indistinguishable. Three forms are to be recognized: Simple plastic, serous, and parenchymatous. The two first named belong to the secondary period of the disease; the last is due to a gummatous infiltration of the organ. The disease is commonly unilateral in situation at the outset, but in fifty per cent. of all cases ultimately attacks the other eye. It occurs most frequently at the average age of the syphilitic subject, that is, in early adult life; and is much more frequent in men, by reason of the greater exposure of the eyes of the male to the accidents incidental to the trades and occupations of life. Simple plastic iritis is the condition in which there is, first, hyperæmia and a plastic exudate from

some portion of the iris, with proliferation of the connective-tissue elements. It may be so slight in its symptoms as to escape detection, and be then accompanied by mild photophobia and vascular injection. In other cases the symptoms are marked and distressing. There is distinctly pericorneal vascularization, sometimes subconjunctival œdema. The large, mobile, tortuous, brick-red conjunctival vessels contrast strongly with the straighter radii of delicate pinkish underlying vessels visible in the sclerotic zone and limited largely to it. Both planes of injection aid in giving a distinctly reddish color to the eye, which is evidently in a state of inflammation. The affected iris is peculiarly dull-hued, its color, as compared with its unaltered fellow, being changed in various shades according to the color natural to the organ in health. It is sluggish to the light, and often its structure is indistinguishable to the eye of the careful observer, because covered with a delicate stratum of the plastic exudate. The latter may extend also over the anterior capsule and give the pupil a cloudy appearance. The aqueous humor may also become turbid. In consequence of these changes the free border of the iris is often agglutinated, in various degrees, at one or several points, to the anterior face of the capsule of the lens, so that when its muscles contract the pupillary outline becomes irregular, being changed from the figure of a circle to that of an interrupted curve, or to semilunar, trefoil, figure-of-eight, or scallop shapes.

Serous iritis is characterized by the exudation of a serous fluid, with hypersecretion of a cloudy aqueous humor, which precipitates a deposit in the form of a delicate, opaque, punctate, or diffuse film on the posterior face of the cornea, the anterior face of the lens, and the membrane of Descemet. There is increased intra-ocular tension, the pupil is immobile and dilated, and the iris is changed in hue. There is less injection of the sclerotic zone than in the plastic form of iritis. Glaucoma may eventually result, from participation of the ciliary body and choroid in the process.

Parenchymatous, gummatous, or suppurative iritis affects the stroma of the organ, whose cellular and vascular elements then proliferate, causing a regular or irregular increase in its dimensions. The attachments which form between the lens and iris are firm and unyielding. Tubercles, nodules, or "condylomata" (gummata), become visible as light- or dark-colored, circumscribed elevations on the surface of the iris, marginal or not in situation, sometimes vascularized as they persist, and attesting the unicity of the syphilitic process in all tissues of the body. Pus may form in the anterior chamber, especially in cachectic subjects.

The diagnosis of these disorders is not difficult, since their association with a syphiloderm, often papular, and the history of the case, usually corroborate the suspicion aroused by the lachrymation, pain, photophobia, and circumcorneal vascularization. The treatment is by the administration of mercury and the iodide of potassium internally, pushed until the system is controlled by these drugs; and by the instillation into the eye of the sulphate of atropine in solution (grs. ij. ad f ℥ j. [0.133–32]). In exceptional cases vesication over the temple may be employed with advantage, or a leech or two affixed near the ear. Opium hypodermatically, or cocaine locally, may be required to relieve pain. The oleate of mercury and morphine also may be applied by inunction over the brow, even where the mydriatic is employed. The eyes should be disused and protected against light (by a darkened chamber or shaded glasses). Paracentesis of the cornea and iridectomy may be required in severe cases at the hands of the ophthalmic surgeon.

A form of iritis has been observed in the first half-year of life of infants, mostly of the female sex, affected with inherited syphilis. It is both unilateral and bilateral, and accompanied by few of the marked subjective symptoms of the disease experienced by adults, but is far more liable to result in pupillary occlusion.

The *lens* is affected in syphilis chiefly by extension to it of inflammation of the delicate organs with which it sustains anatomical relations. Cyclitis, or inflammation of the ciliary body, is for the most part similarly excited by an iritis or choroiditis of the same eye. Very rarely, indeed, a gummatous exudation occurs primarily in its substance, and then commonly the iris is secondarily involved, with characteristic symptoms.

Choroiditis and Retinitis.—Plastic, serous, and parenchymatous inflammations of the retina and choroid are described by authors, the distinction between which forms, as also between inflammations of the two organs, is difficult to establish. The objective symptoms of these disorders, as recognized by the aid of the ophthalmoscope may be described as increased vascularity, ecchymosis, opacity, œdema, and appearance in the fundus of the eye of whitish or yellowish spots. Often the pigment of the choroid atrophies, permitting in one or more places a view of the sclera through its tissue. Blackish areolæ may surround these irregularly bordered macules. In other cases the choroid presents the appearance of maceration; or again, circumscribed nodules (gummata) project above the general level. When there are distinct retinal changes, the point of entrance of the optic nerve is usually pinkish or reddish in shade, œdematous, and surrounded by distended and conspicuous vessels; or hidden from view by plastic deposits upon its surface, or by a fog in the vitreous humor.

The *optic nerve*, when affected with syphilis, is usually involved after extension to it of a retinitis or choroiditis. It is said also to be very rarely primarily infiltrated with a gummatous product. The same is true of the vitreous, which is usually implicated only after syphilitic changes in its investing membranes.

Paralysis of the nerves of the eye is as nearly pathognomonic of syphilis as is iritis, from fifty to sixty per cent. of all cases occurring in syphilitic subjects. Many of these are early phenomena of cerebral syphilis, and hence amblyopia, failure of co-ordination of the ocular movements, and visual disturbances of every kind should be closely investigated at all times when occurring in the victim of syphilis. Paralysis of the third pair of cerebral nerves, the oculo-motorius, is characterized by ptosis of the upper lid, external strabismus, and inability to move the globe upward, downward, or inward. Accommodation is wholly or partially lost, and the pupil is dilated. Paralysis of the sixth pair, the abducens, is, on the other hand, characterized by internal strabismus, amblyopia on the outer side of the vertical axis of the eye, and inability to move the globe outward. Paralysis of the fourth pair, the patheticus, is characterized by amblyopia for all objects lying below the equator of the globe of the eye, and an effort on the part of the patient to correct the visual impressions of objects below that equator by the inclination of the head.

These paralyses may occur singly or in combination; and, with or without them, may be recognized monocular mydriasis, which, albeit occasionally associated with grave cerebral syphilis, the author has seen persist for a year without impairment of co-ordination or other ocular symptom. Unquestionably these paralyses may be due at times to gummatous and other syphilitic changes in the membranes, periosteum, and bones within the cranial vault. Convergent strabismus is readily distinguished from paralysis of the sixth pair by the relief of the squint in the former case when the sound eye is covered. The treatment of these paralyses by the usual method of managing constitutional syphilis is, for the most part, encouraging. Tenotomy may be occasionally required.

The Eye in Inherited Syphilis.—In congenital disease the lids, conjunctivæ, cornea, iris, choroid, retina, and optic nerve, may, one or all, be affected with specific inflammatory changes, or, more commonly, by gummatous deposits resulting in degeneration and ulceration. Grave ocular troubles in early life, especially if coexisting with persistent alterations of the subcutaneous structures, periosteum, or bone, should generally awaken the suspicion of syphilitic disease.

Affections of the Ear in Syphilis.—The external ear may exhibit the lesions of secondary syphilis. Mucous patches, erosions, ulcerations, and the pathological secretions furnished by them, are occasionally sources of

annoyance in the external auditory canal. The underlying submucous tissue, cartilages, and bones may become also the seat of gummata capable of resolution under treatment; and, on the other hand, of degeneration with the production of ulcers. Nodes also form, which are at times of such size as to block up the lumen of the canal and interfere with audition. The middle ear is, more frequently than the external canal, implicated in syphilis, because of its anatomical relations with the nares and fauces But little is known of these complications. Undoubtedly mucous patches, with erosive and ulcerative sequelæ, occasionally form upon the mucous lining of the Eustachian tube or lining membrane of the middle ear. There is usually considerable pain in the latter event; the drum membrane loses its polish; its surface may become the seat of vascularized deposits; or it may be perforated; as a result the ossicles may be loosened or lost, and the mastoid process or other osseous tissue in the neighborhood become carious. Presumably also, nodes may spring, in rare cases, from the bony tissue beneath the investments of all parts of the middle ear; and undoubtedly, if recognized in life, these would explain many obscure cases of deafness. The changes in the internal ear due to syphilis are so obscure as to furnish no basis for study.

Under the heading "Sudden Deafness Produced by Syphilis," Bumstead and Taylor describe a condition in which, after manifest hyperæmia of the drums, both ears are affected suddenly with an extreme degree of deafness accompanied by vertigo, and without obvious changes in any special part of the organ of hearing. In these instances the cochlea and labyrinth have been supposed to be the seat of disease; yet other cases have been explained by disarrangement of the ossicles. Deafness may, however, be due to syphilitic involvement of the brain; and, in this relation, is more common than is generally supposed. (See also Syphilis of the Ear, in the Appendix.)

Aural Affections of Hereditary Syphilis.—Severe, and often remediless, loss of hearing, usually involving both ears, may occur in the subjects of syphilis in the second decade of life. According to Hutchinson, the result depends upon changes either in the auditory nerve or in the deeper parts of the organ of hearing, more particularly the labyrinth. The loss of hearing may be complete and result in deaf-mutism.

Affections of the Respiratory Tract. *The Nose.*—The lining membrane of the nares may be the seat of macules, papules, erosions, mucous patches, and ulcerations, with catarrhal symptoms, the discharge from the nares becoming serous, purulent, or hæmorrhagic. Inspissated masses of these secretions smeared with an offensive discharge are at times expelled. Gummata form in the same region, whose degeneration leads to ulcerative changes in cartilage, periosteum, and bone. This order of sequence may be reversed, the gummatous infiltration first occurring in the osseous structure. The septum, floor, Eustachian tube, pharynx, roof of the mouth, antrum, and even the cerebral meninges, may be attacked by extension of the disease from one point to another. When the bridge of the nose is in this way undermined, a characteristic and highly disfiguring flattening occurs, which is rarely seen in any other disorder save syphilis, traumatism excepted. Cartilaginous destruction is productive of flattening of the tip of the nose. The practically remediless nature of these deformities renders the treatment of all nasal disorders in syphilis a matter of the highest consequence. When the antrum of Highmore is affected there is a peculiar tumefaction, unaccompanied by coloration or change in the skin, of one side of the face, whose treatment may require removal of a tooth, penetration of the floor of the antrum, and the wearing of an obturator for a time. When the Eustachian tube is involved, the drum membrane may be perforated and a purulent otitis media become apparent. Many of these changes, whether vegetative, erosive, or ulcerative in type, are accompanied by fetid ozæna, nasal phonation, and partial or total loss of the olfactory sense. Sometimes osseous fragments, varying in size from a hemp-seed to a finger-nail, are discharged from the nares, the detritus of the carious process as it affects the nasal, turbinated, or other bones. Eburnation and thickening of the bones *in situ* may also result. The internal treatment of these cases is by mercury, iodide of potassium, the mineral acids, and ferruginous tonics. Locally the treatment may be successfully conducted by the aid of mercurial fumigation, but the use of a cleansing douche, followed by lotions containing the bichloride of mercury, resorcin, iodized phenol, potassium chlorate, or boric acid, may be regarded to-day as preferable.

The Larynx.—The vocal cords, arytenoid and glosso-epiglottic folds, and all parts of the mucous, submucous, cartilaginous, and osseous tissue of the larynx, may become the seat of syphilitic changes. Diffuse circumscribed erythema, mucous patches, papules, "condylomata," vegetations, erosions, and gummata may be followed by superficial or deep ulcerations, circumscribed or extensive infiltrations, and cicatrices whose contraction may induce grave and dangerous laryngeal stenosis. Pain, cough, changes in the volume or pitch of the voice, dyspnœa and dysphagia, are not at first noticeable. The supervention of œdema may gradually or rapidly usher in a serious condition. Later, when stenosis of the larynx (the more frequent of the ultimate results) is induced by cicatricial contraction, or (more rarely) by vegetations, false membranes, gummata, or nodes, the voice may be reduced to a whisper or there may be complete aphonia, dysphagia to a slight extent, or dyspnœa even to a grade demanding tracheotomy for the preservation of life. The mucous membrane of the larynx is affected also with a chronic form of infiltration which results in a characteristic induration of the important submucous tissues of the larynx, distinguishable from œdema by its firmness and density. The deeper ulcerations of this organ resulting from degenerating gummata, circumscribed or diffuse in extent, commonly spread from similar lesions in the pharynx, resulting ultimately in destruction of the epiglottis, leaving often in such cases a single wide and ragged laryngo-pharyngeal chasm; or involving the cords, aryteno-epiglottic ligaments, and deeper structures. When the cartilage is involved, crepitation is said to be perceptible after the occurrence of perichondritis; and sequestra have been removed when caries or necrosis has attacked the ossified cartilage. Syphilitic aphonia, obscure as to its immediate cause, as well as paralyses whether of one or both sides, are not to be confounded with syphilitic aphasia. Tuberculosis can now be satisfactorily differentiated from these affections by the modern methods of recognizing the bacillus of that disorder, as well as by the other signs of phthisis and the absence of a history of syphilis and its concomitant symptoms.

The *trachea* may become the seat of lesions similar to those recognized in the larynx; but the absence here of the delicate mechanism required for phonation explains why they are rarer, less conspicuous, and less complicated. The larynx, trachea, and bronchi are usually simultaneously or successively involved, the trachea alone very rarely. All the lesions of mucous surfaces in syphilis, all the vegetations, infiltrations, and degenerations, may here be noted, including extra-tracheal abscess from perforation. Stenosis from cicatricial contraction may here also induce fatal results. The internal treatment of laryngeal and tracheal syphilis is that of the disease in general. Locally, the parts may be sponged with solutions of boric acid, benzoin tincture, eucalyptol, or dusted with iodoform, or tannin in fine powder, reduced if desired. The galvano-cautery is best employed in the surgical management of membranoid occlusions, which are, it should be remembered, quite uninfluenced by large doses of the potassic iodide. The last-named drug is indeed, in some cases, credited with producing a form of laryngeal œdema. Dilatation with bougies has not won for itself much favor in the management of these cases. The use of tobacco, both by smoking and chewing, is to be interdicted in all cases.

The *bronchi*, it can scarcely be questioned, may become the seat of the syphilitic changes described in con-

nection with the larynx and trachea. Few cases, however, have been carefully studied, though stenosis following ulceration has been recognized post mortem.

The *lungs* may be the seat of a syphilitic infiltration affecting usually one side of the chest only, and then the upper, middle, or lower lobe. The pulmonary tissue becomes so dense in these cases as to be impermeable to the air; and yellowish points are visible here and there in the relatively small patch of consolidation, due to the irritation of the parenchyma by the sclerotic nodule.

These sclerosed portions of the lung by their contraction induce either stenosis or ectasia of the normal canals and chambers in the vicinage. Under the microscope the sclerosis is seen to be made up of bundles of firm connective tissue, between which appear stellate, fusiform, and roundish cells, with a granular detritus. The vessels of the part are first engorged with blood, and later choked with the stasis of their contents.

Pulmonary gummata, or circumscribed syphilomata, of the lung rarely form at the apices of these organs, but are found in all other parts. They are grayish, semi-solid masses, varying from the size of a pea to that of an egg, set in the pulmonary parenchyma, surrounded always by an opalescent, fibrous, basket-like capsule, and as they grow older often exhibit one or more yellowish points in their mass where caseation has begun. Softening in these progresses from centre to periphery, and the contents may find exit by the portal of a neighboring bronchus with a secreting cavity left behind; or resorption may occur with the result of leaving a fibrous mass in the lung tissue, having a cheesy centre. These conditions may be found in one and the same lung, gummata forming in cavities left by others that have degenerated, fibrous sequelæ of resorption, and contracting cicatrices. Often the pleura and bronchi are either involved in the same process or exhibit the irritating effects of the pulmonary neoplasms. Microscopically, the centre of these gummata is found to be made up of granular connective tissue, in process of degeneration, and highly refractive granules. The fibrous tissue is concentrically wrapped about them, the cellular elements nearest the core having often undergone in part fatty metamorphosis. Still more externally lie irregular masses representing a small-celled infiltration, which in places blocks up the alveoli. The symptoms of these lung-changes of syphilis are largely those of non-specific inflammatory disorders, viz., bronchial catarrh with expectoration of muco-pus; diminution of sonority in percussion; limitation of the respiratory area in affected parts of the lung; dry and moist râles; prolonged expiration; and dyspnœa. The author has published a report of a case of severe hæmorrhage in a patient affected with syphilitic pulmonary sclerosis, with complete recovery after appropriate therapy. In the event of degenerating gummata of the lung, the symptoms are those of pulmonary caverns, whatever be the cause, hollow gurgling râles, pectoriloquy, raucous voice, etc. The diagnosis is established by the history of syphilis and any concomitant symptoms present; by the relative immunity of the pulmonary apex; by the smaller number and larger size of gummata, as contrasted with miliary tubercles; and by the absence of the bacilli of tuberculosis, of the signs of hydatid cysts, and of neoplasms of other diseases. The treatment is that of syphilis in general, with such remedies as are specially indicated by the pulmonary symptoms present.

Affections of the Digestive Tract. *The Mouth.*—As the lining membrane of the mouth is more often exposed to the eye of the practitioner than any other mucous surface in the body, the symptoms it exhibits in the victim of syphilis may be regarded as representative of mucous lesions in general. They are all properly in alignment with the cutaneous lesions, the modifying influences being chiefly heat, moisture, and motion; the latter incidental to the performance of the important functions of the mucous cavities. Thus the buccal cavity is often the seat of diffuse or circumscribed erythema, in dull red shades, faucial or palatal in situation, with defined or irregular outlines, accompanied by infiltration, œdema, and often by erosions. These may be multiple, pea-sized patches, or a single sheet of diffuse blush. The former, after maceration, may, by either a vegetative or a degenerative process, form papules, mucous patches, or ulcers. In malignant cases a dull-red erythema often precedes the gangrenous crateriform ulcer which opens, almost as at a stroke, the oral and nasal cavities by a communicating chasm.

Mucous Patches (Mucous tubercles, plaques muqueuses, moist papules, etc.).—The larger number of these lesions appear in the mouth and about the anus, though they are to be seen near all the mucous outlets of the body. They are far more common and more severe in the mouth of men than of women, on account of the tobacco habits of the former. They are early and late lesions of syphilis, and are represented in the symptoms of relatively few diseases not syphilitic. They consist of roundish, ovalish, or irregularly shaped disks, or longer, narrow, indefinitely outlined bands of a delicate rosy hue; grayish or opalescent in color; often granular and elevated about a millimetre above the general level of the surface where they appear. Many of them look as if covered with a delicate pellicle. When of a pinkish or reddish shade, they represent merely a stage of hyperæmia of the membrane; when opalescent, as if pencilled by the silver crayon, a stage of maceration of the previously infiltrated epidermis; when granular, a stage of attempted repair, the loosened pellicle having been removed by friction or otherwise, and the surface beneath forming a new epithelial envelope. They may form upon a chancre when undergoing its so-called "transformation *in situ*," already described. When located in quasi-mucous situations, viz., those portions of the skin in the vicinity of the mucous outlets subjected to friction and kept moist and warm (inner faces of the thighs, inside of the toes, etc.), they may vegetate and produce the condyloma, a lesion frequently seen about the anus and genital region, more particularly in syphilitic women of filthy habits. These are usually circumscribed, multiple, roundish, or irregularly shaped, wart-like elevations, smeared with a whitish mucus, highly contagious, and of especially disgusting odor when seated about the ano-genital orifices. In the same situation they are remarkable for the production of a sensation of itching, rarely awakened by other syphilitic lesions. Occasionally they are dry. They are, as a matter of fact, merely papular lesions, flattened by apposition of the surfaces between which they are developed, or vegetating as the clefts in these same surfaces permit of such a growth, secreting because moist and macerated, and itching because irritated by the same agencies. When exposed, as about the bearded lips and nares, they are dryer, and browner, or duller red in hue. They occur in and about all the mucous outlets, and affect all mucous surfaces, with a marked predilection for the neighborhood of the muco-cutaneous borders. They are exceedingly common in both infantile and inherited syphilis. They may become cracked, eroded, and superficially or very deeply ulcerated. Their excessive proliferation produces enormous masses of secreting, wart-like, softish growths, described by authors as frambœsioid condylomatous syphilodermata.

The mucous patches of the mouth are less elevated and more opalescent than others, and appear upon the inside of the lips and cheeks, gums, uvula, palate, tonsils, and pharynx. They should never be confounded with the transitory, minute, usually distinctly circular, aphthous ulcerations to be seen in healthy adults after a fit of indigestion; nor with the persistent, much firmer, leathery disks, or striated or ribbon-like streaks, described as psoriasis linguæ, leukoplakia buccalis, etc., which, as is now well known, may be the earliest epitheliomatous transformation of a mucous membrane; nor, lastly, with the so-called "smokers' patches" (plaques des fumeurs, etc.), which in many cases, it can scarcely be questioned, represent buccal lesions in a veteran of syphilis.

The tongue may display a wide variety in the lesions of syphilis. In the order of gravity may be named: Multiple, macular lesions, the size of a pin-head, abundantly spread over its upper surface; mucous patches in all

forms, particularly over the edges and tip, often forming where the organ is rasped by the rough edge of a carious molar tooth; flat, circular papules, the size of a bean and larger, elevated a millimetre or two above the general level; circumscribed and diffuse, superficial or deep (parenchymatous) scleroses, usually developed upon the upper surface of the organ and near its mesian line, characterized by irregular increase of bulk and almost cartilaginous density, which may result in resorption and atrophy or ulceration; and, lastly, superficial or parenchymatous gummata, submucous or muscular in site, occasionally single, often multiple, which also may disappear by resorption or degenerate by ulceration. One of the remarkable features of disintegrating syphilitic, as distinguished from other neoplasms, of the tongue is the relatively slight damage apparent after completion of repair. The author lately examined a patient's tongue two years after closure of a crater, the size of a pigeon's-egg, left by a deep gumma, with the result of finding merely an irregular band-like scar to indicate the site of the lesion. These all are to be distinguished from epitheliomata, which are more voluminous, more hæmorrhagic, less deeply excavated, more irregular in mass, and more painful; as also from colloid lingual tumors (so-called "hygroma" of English authors), with the appearance of vesicles on the upper surface and enormous asymmetrical increase in the bulk of the organ in childhood; and, lastly, from tuberculosis of the organ, rare of occurrence, to be recognized only by its histological characters.

The *maxillary bones* may undergo necrosis as a result of syphilis. The most common site of the accident is the central part of the dome of the hard palate. There is first a dull-red erythematous swelling of the membrane and submucous tissue, which in severe cases may seem to melt away like wet paper, leaving a conical perforation through which communication is opened between the oral and nasal cavities; in other cases an abscess forms and bursts, after which the bone is laid bare and exfoliates in larger or smaller masses from time to time. Necrosis of the alveolar processes usually occurs in the upper jaw. Gummata of the soft palate often form insidiously; are circumscribed or diffuse; at first firm, later softish, tumors, varying from the size of a pea to that of a small nut, or in patches of thickening. Absorption or ulceration may result, and the latter often rapidly, in consequence of the lax and unsupported tissues involved; the process in grave cases opens (by destruction in whole or in part, of the uvula, pillars of the fauces, and velum) a wide chasm between the fauces and the posterior nares. Interference with the Eustachian tube often produces temporary deafness. The voice is disagreeably nasal, deglutition is often difficult in the erect posture (patients with extensive tissue-loss will often assume singular postures, by which they can even succeed in swallowing liquids without the passage of the latter into the nose), and the pain in general is quite disproportionate to the severity of the damage. Marvellous are the reparative results when, as is usually the case under sound management, repair ensues. The remaining fragments of the velum palati contract adhesions to the posterior pharyngeal wall, the chasm contracts, and the expert can trace the picture of the mischief that has occurred when inspecting only the narrow and distorted chink left after contracture is complete.

Fournier only has reported a case of syphilitic involvement of the sublingual gland.

The *pharynx* may become the seat of macules, papules, mucous patches, gummata, and ulcers, which in many cases are formidable. The latter may spread from the posterior nares and extend downward into the œsophagus, or backward, so as to produce destructive effects upon the periosteum of the vertebræ and the structures they protect. Occasionally, patients long neglected or badly treated exhibit gigantic caverns, including what were once the nasal, buccal, and pharyngeal cavities, the whole lined with a granulating or secreting, and ulcerated membrane. Even in those extreme cases where one is disposed to wonder even at the prolongation of life, repair ensues and emphasizes the striking, almost pathognomonic, distinction between the damages inflicted by syphilis and all other destructive diseases.

The *œsophagus* is said to be very rarely the seat of syphilitic lesions which, after ulceration, may produce stricture, either spasmodic or organic, resulting in serious danger to life.

The *treatment* of all these lesions is practically the same. Internally, mercury and the iodide of potassium are essential, the latter often in the largest permissible doses, to save important organs. Care of the patient's nutrition is in most cases imperative. Locally, the nitrate of silver, sulphate of copper, chlorate of potash, tannin, resorcin, acid nitrate of mercury, nitric acid, and tincture of iodine, may be employed in strength varying according to the requirements of each case—the first-named in solid stick or solution of a strength of from five to sixty grains to the ounce (0.33–4. to 32.0). By spraying, pencilling, dusting, washing, and gargling, these preparations may be used, with the greatest advantage, a number of times throughout the course of the day. The following are excellent formulæ for gargles:

℞.	Potass. chlorat.	ʒ j.	4.
	Mel. despum.,		
	Myrrh. tinct	āā f ℥ ss.	16.
	Aq. dest.	ad f ℥ iv.	128.

M. S.—Gargle. Use diluted as required.

℞.	Potass. chlorat.	ʒ j.	4.
	Infus. lini.	O j.	500.

[Bumstead and Taylor.]

℞.	Acid. carbolici.	ʒ j.	4.
	Glycerin,		
	Spts. vin. rectif.	āā f ʒ ij.	8.
	Iodin. tinct	f ʒ ss.	2.
	Aq. dest.	ad f ℥ j.	32.

M. Five to fifteen drops in a third of a tumbler of water for gargle or lotion.

The tooth-brush, in all cases, is to be regularly employed twice daily; if the patient is unaccustomed to its use the mouth should be well cleansed and the gums rubbed with a bit of soft muslin on the finger, dipped in water to which a few drops of the tincture of myrrh and cinchona has been added. Tobacco is to be, in every form, absolutely interdicted; and all very hot and very cold, and irritating articles of diet are to be excluded (*e.g.*, hot coffee, ice cream, vinegar, spirits, spices, etc.).

The *stomach and intestinal canal* may become the seat of syphilitic lesions of the type seen upon the other mucous surfaces. Huet, Cornil, Klebs, and others report gummata of this part of the digestive tract; Leudet, Virchow, and Fauvel describe diffuse infiltrations of portions of the tube; Engel, Fioupe, Cullerier, and others, perforating ulcers (probably due to gummata) as well as scleroses resulting in contracture, even productive of sufficient irritation to light up a peritonitis near a stricture of the colon. It should not be forgotten that a long list of functional disorders of the alimentary canal might be enumerated as of occurrence in the syphilitic subject, which are often due to the toxic influence of the disease (cachexia, etc.); to the effect of certain of the medicaments ingested or externally applied for its relief; and to improper alimentation or hygiene.

The *rectum* may become the seat of a series of important changes due to syphilis. Women are more liable to be thus affected than men in the proportion of eight to one, a preponderance which has been referred to the anatomical differences between the sexes; to the physiological fluxes of women; previous pregnancies; and to unnatural or excessive coitus. Chancroids, occurring as they do frequently about the anus of women, may result in induration of the submucous tissues, accompanied by purulent and sanguinolent discharges, constipation, or looseness of the bowels, and painful defecation. This condition is to be carefully distinguished from syphilitic stricture of the rectum.

The syphilitic affections of the rectum may, perhaps, include the category of syphilitic lesions of mucous surfaces in general. The most important, however, are

those characterized by ulceration or gummatous changes. The former may extend from without inward, from the perianal region to an inch or more within the sphincter; or may begin by one or several points of ulceration in the latter situation. The so-called "ano-rectal syphiloma" is a cylindriform, gummatous, non-ulcerated infiltration of the entire circumference of the ano-rectal walls, capable of producing stricture by transformation into fibrous tissue. It is, however, an error to suppose that stricture of the rectum not due to chancroids, but syphilitic in character, always conforms in type to the syphiloma. The author has at present under his care a middle-aged woman, whose husband and two children are victims of severe syphilis, and whose left lower extremity is extensively seamed with perfectly typical syphilitic cicatrices. There are in this case four abscesses in the nates, communicating by fistulous sinuses with the bowel and vagina, the syphilitic stricture of the rectum being represented by a sharply defined, thin, annular coarctation of the rectal wall, with a submucous gummatous infiltration strictly limited to the ring of the coarctation. It is evident that only in exceptional cases, probably during the period before contracture has set in, can internal medication accomplish practical results in these cases. Dilatation, or division of the stricture by the knife or galvano-cautery, is usually required, with free opening of all abscesses and sinuses, and observance of strictest antiseptic precautions with bichloride dressing. The future is, however, rarely promising for these cases, many women who are the victims of the disorder having their health profoundly impaired by previous suffering and disease.

The *liver*, like the intestinal canal, may suffer during the period of syphilis by functional disorders, which may depend upon slight structural changes participating in the process which results in the cutaneous exanthem. The icterus probably originating in this way, which may somewhat precede or accompany the first syphiloderm, has already been described. It may be accompanied by hepatic congestion and by symptoms of malaise, hebetude, cephalalgia, and even slight pyrexia. The tertiary forms of syphilitic involvement of the liver are well marked. General, more commonly partial, interstitial hepatitis, affecting chiefly the capsular and ligamentous attachments of the organ, produces a distortion of the gland by contracture of fibrous bundles which, springing from these attachments, penetrate the hepatic parenchyma and divide it into uneven lobulations and irregular masses separated by furrows. There is at first increase, and later diminution, in the bulk of the organ, with the usual symptoms of cirrhosis. Hepatic gummata are of more frequent occurrence, and in "galloping" cases may be seen within six months after infection. They are usually grouped in clusters of from six to a dozen lesions, varying in size from a large pin-head to a small nut. Centrally they contain roundish cells and granules in a delicate connective-tissue reticulum, surrounded by a fibrous envelope, and embedded in dense hepatic tissue. The symptoms in mild cases are probably scarcely sufficient to indicate the nature of the affection. In others, disturbance of the alimentary canal (icterus, constipation, dysentery); pain in various degrees, limited to the hepatic region or radiating from it; and, very rarely, morbid changes perceptible on palpation of the enlarged, or previously enlarged and subsequently shrunken, organ, may first point to the precise nature of the trouble.

Gummata of the liver are to be distinguished from hydatid cysts; carcinoma (of advanced years); hepatic abscess (in persons who have been long resident in tropical countries); tubercles (usually softer, more cheesy, more purulent in the centre); and the rare forms of sarcoma of the liver. The prognosis of hepatic syphilis is usually not grave.

Amyloid degeneration of the liver may be the result of syphilis as of other diseases. There is increase in the bulk of the waxy-looking organ, the hepatic cells becoming enlarged after involvement of the swollen hepatic capillaries. Often there are coincident amyloid changes in the heart and spleen. The symptoms of hepatic gummata are as obscure in many cases as in syphilitic cirrhosis. There may be ascites, hæmorrhage from the portal vein, and dyspnœa. The treatment is largely that of syphilis in general.

The *spleen* often enlarges in those early periods of syphilis when the lymphatic glands tumefy. Commonly the enlargement subsides as the disease progresses or is modified by treatment. Syphilomata of the spleen (gummata) are rarely observed, but have been recognized in both circumscribed and diffuse forms. Splenic gummata are yellowish, softish nodules, from the size of a pin-head to that of a small nut, set in a dense splenic tissue of unusual dryness. In diffuse forms, the organ appears to be in part hypertrophied and dark brown in color. Later, islets of grayish sclerosed tissue become apparent in this mass, whose involution leaves cicatriform depressions. There is reason to believe that rarely a perisplenitis may be lighted up by these changes, leading to the formation of whitish patches of almost cartilaginous density. The clinical symptoms of syphilis of the spleen are obscure.

The *pancreas* is said to be occasionally the seat of changes which have been supposed to represent the circumscribed and diffuse syphilomata recognized in the liver and spleen.

AFFECTIONS OF THE CIRCULATORY ORGANS.—*Myocarditis*, recognized chiefly in post-mortem examinations, may be a late complication of syphilis, which affects men more often than women in the proportion of six to one. Softish, yellowish gummata, from the size of a nut to that of an egg, as well as circumscribed and diffuse sclerosis, have been recognized in the ventricular walls and auricles of both sides. Plastic or fibrous metamorphosis of the muscular tissue about any of these lesions may occur. Whitish diffuse infiltrations, firm, or of the consistence of a sarcoma, with round-celled infiltrations and vegetations, may affect the endocardium or muscular tissue; and the same changes in the pericardium may result in partial or total obliteration of its sac. These commonly originate in sub-endocardial or sub-pericardial gummata. Wagner, Lancereaux, and a few others have reported gummata limited to these serous membranes. The symptoms excited by these changes are dyspnœa, palpitations, cyanosis, præcordial distress, and angina pectoris. The prognosis is naturally described as grave, since all the identified instances of this affection were recognized in the bodies of the dead. It is reasonable, however, to suppose that syphilis here, as elsewhere, exhibits its usual amenability to treatment in the case of patients with symptoms not diagnosticated in life.

Arteries and Veins.—The femoral, jugular, saphena, and other veins have been reported affected with a phlebitis due usually to the pressure exercised by a gummatous tumor in the vicinity. A sclerous phlebitis, in which the intima was first attacked, has also been recognized post mortem.

The capillaries and arteries also may be primarily or secondarily involved. In the latter case it is commonly the result of compressive or destructive effects exerted by syphilitic processes in adjacent organs. Syphilitic endarteritis, however, is much more common; and recent investigators, including Virchow, Heubner, and others, have revealed its pathology with sufficient clearness. These lesions are more commonly observed in the smaller cerebral arteries, but the carotids and other vessels are occasionally involved. The definite limitation of the disease to a single patch is declared by the rapid appearance of whitish, opaque nodules, the size of a millet-seed, composed of small, roundish, or spindle-shaped cells, which may be agglomerated into a firm, fibrous mass, from the size of a pea to that of a nut, obliterating the lumen of the invaded artery by thickening of all its investing coats, and producing eventually either rupture or an atrophic or cicatriform relic of its existence. This infarction is remarkable for the indirect results it produces, including cephalalgic, aphasic, paretic, paraplegic, and even comatose, symptoms.

THE GENITO-URINARY ORGANS.—Secondary and tertiary, as well as primary, symptoms of syphilis are disclosed in the genito-urinary tract of patients of both sexes.

The *penis* may become, in one part or another, the seat of circumscribed tertiary syphilitic infiltrations, as well as of gummata.

Lesions of this nature may be subcutaneous, or there may be nut-sized masses deeply lodged in the substance of the corpora cavernosa, or in the submucous tissue of the urethra. Some of the lesions discovered post mortem, and described as "chancres of the deep urethra," are really tertiary ulcers resulting from broken-down gummata of the prostatic or membranous urethra. Jullien figures a cavern of the cutaneous surface of the penis originating in this way in one of Langlebert's patients. Bumstead and Taylor describe tubercles of syphilitic origin near the furrow at the base of the glans.

Any part of the *testicles* may be affected with syphilis. The *epididymis*, when involved, may display either an early or late form of syphilitic epididymitis.

The early form, first described by Dron, in 1863, may be observed at any time between the third and thirtieth months after infection. The disorder bears no relation to gonorrhœal epididymitis. The globus major, or head, of the organ, much more rarely the globus minor, is attacked and either insidiously or acutely affected, producing a roundish or squarish, circumscribed tumor, from the size of a bean to that of a small nut, which has been compared to a "monkey-nut screwed to the testicle." One or both organs may be involved, successively or simultaneously, and the globus minor may be attacked later. It is amenable to treatment, and commonly disappears without unfortunate sequelæ.

The late form is often connected with gummatous changes in the testis proper, but very rarely arises independently of the latter. Here also the globus major is more often attacked; and resolution, as is the case with tertiary deposits in the testis proper, may be followed by atrophic changes.

Syphilitic *orchitis*, sarcocele, or albuginitis, may be a late secondary or tertiary symptom of syphilis, involving one or both organs simultaneously or in succession. In these cases, the body of the testicle is involved, often without the production of pain, in a smooth, uniform, and firm swelling, which may be due in part to enlargement of the testicle, and in part to a moderate grade of hydrocele concealing the irregularities perceptible later in the body of the organ. In other cases, this body can be recognized by palpation as the seat of one or several masses, from the size of a pea to that of a small nut, which may be at first isolated and circumscribed, but later become fused into a solid, resisting mass having the general shape of the testicle, but often three or four times larger. Under energetic treatment, resolution of these masses is accomplished; but obliteration of the vasa deferentia and atrophy, or fatty, fibrous, cartilaginous, amylaceous, even osseous metamorphosis of the parenchymatous tissue of the gland, may follow the absorption of the neoplasm. In this way the testicle may be, after completion of this cycle of changes, represented by merely a bean-sized mass of fibrous tissue. Suppuration and ulceration of the tunics almost never result, though a few authors have reported a resulting "fungus of the testicle."

Pathologically studied, the glands are found to be the seat of vascularization and proliferation of connective tissue, resulting in the production of fibrous trabeculæ traversing the organ in various directions, but always attached to its thickened investments, resulting by contracture in compression and atrophy of the secreting cells of the tubules. In other cases, true, grayish or yellowish gummata are found in the testis, single or multiple, diffuse or circumscribed, from the size of a pin-head to that of a pigeon's egg, environed by fibrous capsular coats. These commonly disappear by absorption; even in the rare cases of disintegration and the formation of "fungus of the testis," recovery ensues under proper treatment.

All syphilitic lesions of the epididymis and testis are to be distinguished from the gonorrhœal, the cancerous, the sarcomatous, and the tubercular. The blennorrhagic affections of the epididymis are acute in type, painful, attack the tail of the organ by preference, and are usually preceded by an unequivocal history of urethritis and discharge. The neoplasms of cancer and sarcoma in the testicle are usually accompanied by inguinal adenopathy, severe pain, systemic cachexia, extensive damage to the parts affected, and proneness to disintegration. Tuberculosis is far more common in young men virgin of all venereal antecedents, usually with tuberculosis of the prostate gland and marked dysuria. Almost invariably the bacillus tuberculosis may be recognized in the secretion obtained by "milking" the prostate. The treatment internally is by the potassic iodide and mercury. Locally, suspension is to be recommended; hot fomentations for relief of pain when such exists; and applications of salves containing lead, mercury, belladonna, or opium. The oleate of mercury and morphine, mercurial plaster, white precipitate salve, or the compound iodine ointment, may be applied. Strapping, as employed for relief of gonorrhœal epididymitis, may be practised with advantage in some cases. The prognosis is not unfavorable as regards the health of the patient; but, after double syphilitic orchitis, the patient may have complete aspermatism. The *prostate gland, vasa deferentia, common ejaculatory ducts*, and *vesiculæ seminales* are all probably the seat at times of syphilitic changes, the characters of which are not known.

In women the *labium majus*, usually one, occasionally both, may be the seat of gummatous changes due to syphilis. These may be late and unique manifestations of the disease. Often nothing can be gathered in cases of this sort as to the history of syphilis, a not uncommon experience in the infected of that sex. The organ is found, when examined, to be wholly or in part the seat of a dense, smooth or irregularly lobulated, vertically disposed tumor, very closely resembling in size and external appearance the scrotum which contains a testicle affected with syphilitic orchitis. It is usually an exceedingly indolent affection, lasting for years, rarely occurring at the outset till three or four years have elapsed since infection. It is often diagnosticated as "elephantiasis" of the labium. Disintegration of the mass by ulceration is rare.

The *syphiloma of the vagina* is similar to the lesion described above in the date of its occurrence, its exceedingly indolent career, and its existence for months without a single coincident symptom of syphilis to substantiate the diagnosis. Many of these cases have been recorded, treated, described, and even illustrated as "lupus of the vagina," which disorder is even rarer than this exceedingly rare manifestation of syphilis. When recognized, the vagina is converted into a thickened cylinder of tissue infiltrated with gummatous material, which greatly restricts the distensibility of the vaginal walls. In some of these cases the finger can with great difficulty be introduced into a channel through which viable infants have been ushered into the world. Irregular projections of the inextensible vaginal membrane, club-shaped, knobbed, granular, eroded or ulcerated, represent points where the larger submucous gummata are undergoing extreme development or ulcerating. These lesions break down more frequently and more disastrously than is true of the gummatous metamorphoses of the labia. Occasionally the ostium vaginæ is converted into a vast gummatous ulcer, invading the vestibulum and even the urethra. In one very severe case, the author has seen the rectum participate in the change.

The neck and body of the *uterus* exhibit more rarely and to a much less marked degree similar changes; induration, tumefaction, erosion, and ulceration of the mucous lining are reported by authors.

The Fallopian Tubes and Ovaries.—Lancereaux and Lecorché, respectively, have reported instances of diffuse and gummatous changes in the ovaries. In the case reported by the first-named author, there were two egg-sized tumors with long diameters parallel with the broad ligament. Bouchard and Lepine, quoted by Jullien, describe a single case of syphilitic salpingitis.

The kidneys undergo changes both in early and late syphilis. The phosphates and chlorides may be unchanged in the urine; urea may be quantitatively in ex-

cess, and albumen occur in quantities as great as in Bright's disease. Fifteen years ago, the author had under observation a case of severe albuminuria following syphilitic changes in the kidney of a man who is to-day living and well. Ten years ago, the author had under observation a severe case of anasarca following marked albuminuria, the patient, a young man, losing for five days ten pounds by weight daily in the Turkish bath. When recovery was complete, the patient was examined, and two years ago found free from disease. Similar observations have been made by most experts. Glycosuria has appeared and disappeared under precisely similar circumstances in syphilitic subjects. By some authors, these several conditions are claimed to be the results simply of the cachexia which may affect syphilitic as well as non-syphilitic patients, producing thus the amyloid, waxy, and other metamorphoses recognized in other cases. Without denying the possibility of such accidents, the author calls special attention to the striking fact that some of these cases bear the special imprint of syphilis in this, that after the exhibition of alarming symptoms, a complete, rapid, and permanent recovery may ensue after energetic treatment by mercury and, more often, by the iodide of potassium.

Syphilitic sclerosis and gummata of the kidney are late lesions of syphilis, and of rare occurrence, the last named being decidedly the rarer of the two accidents. In the diffuse form of syphilitic nephritis, there is usually a cycle of vascularization and tumefaction of the cortical portion, followed by interstitial proliferation, attachment of capsule to cortex, and formation of irregular, small or large nodules and projections from the surface whose exterior gross appearances suggest the similar lobulations of the syphilitic testicle. In some places these undergo lardaceous, amyloid, and other degenerative changes resulting in cicatrices. Precisely as the seminiferous tubules of the testicle are choked and eventually reduced to atrophy, are the glomeruli and uriniferous tubules of the kidney compressed, their channels obliterated, and their functions arrested. Here and there, on section, yellowish points or streaks of fatty metamorphosis are visible upon a granular surface; or the totality of the organ may be changed to a dead whitish color.

Gummata of the kidney are developed in both the cortical and pyramidal portions. They are single or multiple, grayish or whitish, definitely circumscribed masses, from the size of a pin-head to that of a pigeon's egg, with a whitish or reddened and vascular, fibrous envelope like a capsule. The centre is firm or cheesy, according to the age of the gumma; and the body of the lesion is made up of elements derived by proliferation from the connective tissue of the renal stroma. The subjects of these several complications of syphilis may suffer from vague pains, changes in the eye, peritoneum, pleura, and nervous centres, as well as ascites, anasarca, lumbar pain, hæmaturia, and albuminuria. The prognosis is decidedly less grave than in non-specific renal affections of similar type.

THE NERVOUS SYSTEM.—Affections of the nervous system may be early or late symptoms of syphilis, and are commonly the results of morbid changes in contiguous structures, such as bone, vessel, or investing membrane. They are much more common in men, chiefly because of the greater tax levied upon that sex in the demand for physical and mental strain constantly made in business.

The literature of nervous syphilis, most of which has been contributed during the last decade, has been both voluminous and valuable. In the following paragraphs it will be possible merely to trace the outlines of the important advances which have been made in this special field. The clinical pictures presented may be briefly named as follows:

Headache, insomnia, and irregular performance of functions of many of the organs of the body (eye, ear, heart, muscle, liver), dependent upon nervous disturbance, are not infrequent in the early periods of syphilis. The headache of this stage of the disease is often persistent and obstinate. It may be frontal, temporal, or occipital in situation, and of the moderate grade from which few infected subjects are wholly exempt, or severe, with intense nocturnal exacerbation, eliciting groans from the sufferer. This distressing complication of the disease may endure for only a few days, or last for weeks or months, proving eventually a mere precursory symptom of cerebral syphilis. Jullien, with certain others of the French school, lays stress upon the return or exaggeration, at this time, of the nervous symptoms displayed previous to infection by the subjects of hysteria, alcoholism, other cerebral affections, and epilepsy. Mild nervous manifestations are recorded by observers in this connection, including anæsthesia, analgesia, circumscribed hyperidrosis, and hypertrichosis, and cutaneous sensations of coolness, heat, formication, and tingling. Many of these features are such that the pathological changes on which they depend are necessarily unknown, or can be estimated only by reasoning from analogy. The supposed cerebral syphilis *sine materia* has for its basis only the non-recognition of structural changes where autopsies were made after the exhibition of well-marked nervous symptoms. In such cases, the possibility that the actual physical basis of the morbid phenomena was simply not discovered cannot be properly ignored.

When a patient is actually affected with *cerebral syphilis*, the unmistakable features of the accident often follow, as indicated above, the milder symptoms. The headache, which was at first simply annoying or tolerable, sets in with paroxysms of distress which make the patient dread the hours of the night as a period of torture. Constant or intermittent grinding, boring, or hammering sensations are referred to the whole or any one of the regions of the head described above. The patient will grow eloquent in declaring that the head feels as if it were screwed in a vice, riveted with iron bands, hammered upon an anvil, etc. Under treatment even this condition may yield in a few days, or, defying all skill (a rare complication), go on to the extreme conditions described later. At times definitely circumscribed regions of tenderness may be appreciated by both patient and physician, the latter by the pain evoked in percussion of the cranial vault. Insomnia, vertigo, intellectual hebetude, apathy, melancholia, and other morbid mental states, photophobia, and marked cachexia, are the usual concomitants of this state. When the disorder progresses uninterruptedly to full evolution, the patient becomes weaker, takes to the bed day and night, may exhibit some mild ataxic or paretic symptoms, usually goes into delirium, and presents the picture of one affected with utterly hopeless cerebral disease. Yet here, as so often in the history of this singular malady, he is really far from such a hopeless state, and thus furnishes the diagnostician with a clue to the syphilitic origin of the disease. Such a patient, properly treated, may rise from his bed, regain his flesh, return to his occupation, and live out his natural days, so far as regards the disorder under consideration.

Many odd features may be presented in the course of this complication. There are patients thus affected who present singular hallucinations; yet others suffer from vague terrors, dreading self-destruction or attacks from enemies.

Chorea, or at least choreic symptoms, may be recognized in some patients of this class. Spasmodic contractions may affect one or a group of muscles, either before or after the occurrence of paralytic symptoms, or independently of the latter. There may be slight, severe, transitory, remittent, or constant contractions of muscles of the head or extremities. One of the author's patients had a persistent, rhythmical swaying of the head from side to side, which lasted during the hours of wakefulness for a fortnight.

Aphasia, partial or complete, continuous or intermittent, may be the sole symptom of nervous syphilis, or occur before or after some of its grave complications. Often it is of sudden onset—one of the author's patients, for example, presenting himself at a bank in order to secure a foreign draft, and finding it on the instant impossible to make himself understood.

Paralysis, sensory or motor, partial or complete, usually succeeds a prodromal stage in which the patient has complained of obstinately persistent headache or some other premonitory symptom of cerebral disorder. The paralyses of the motor muscles of the eye belonging to this group of disorders have been already described. In a similar way the nerves of special sense, not only those of vision and hearing, but of olfaction and gustation, are totally or partially deprived of sensitiveness to external impressions.

Hemiplegia, occurring suddenly in a patient under fifty years of age, is, in the great majority of all cases, of syphilitic origin. It may be of early or late, sudden or gradual occurrence, and constitute a mere paresis of a group of muscles on one side, or much more rarely, a complete motor paralysis of one half of the body. It is usually preceded by cephalalgia, vertigo, lassitude, and neuralgia, with anæsthesia or tingling of the parts about to be affected, or mild choreic, rarely convulsive, seizures. Usually, after well-marked prodromal symptoms have been exhibited for some days or weeks, the patient awakes from sleep to find himself more or less unable to move one or both limbs of one side ; or the attack comes on in the hours of the day, the patient falling to the ground in a state of partial unconsciousness. The leg only is most commonly affected ; at times it is followed by involvement of the arm. Rarely the arm alone is affected. The bladder and rectum may participate in the resulting symptoms by loss of power to expel their contents. Alternate paralysis of the facial muscles is occasionally noted, *e.g.*, the right leg and the left side of the face. There may be dilatation of the pupil of the eye on the sound or affected side, with or without ptosis and involvement of the oculo-motorius. With these symptoms are occasionally associated total impotence, which may even survive the paralytic symptoms in the extremities, muscular tremors, and contractures. Sensory disturbances are few ; rarely there is complete sensorimotor loss. The affection is commonly attributed to an obliterating endarteritis. The prognosis in most cases is favorable.

Epilepsy is simulated in syphilis, under the influence of which epileptiform seizures occur. They are far rarer than hemiplegic complications. With or without premonitory sensations comparable to those experienced in the aura, both the *grand mal* and *petit mal* are represented in syphilitic seizures. There is, in the first case, the usual precursory severe cephalalgia, followed by distressing sensations in the extremities or about the heart, or singular creeping sensations of chilliness. Jullien insists that during these attacks the patient, even if unable to speak or to move, never wholly loses consciousness and never utters the cry, an important diagnostic distinction. The patient may fall as if shot, and exhibit tonic, followed by clonic, convulsions during a portion of the time, but rarely throughout the whole period occupied by a seizure. These convulsive movements do not notably affect all of the muscles of the body. The patient may foam at the mouth and bite the tongue or lips, though often, with marked convulsive seizures, these symptoms are absent. The intervals between these crises may be but a few hours, or days, or several weeks. They tend to multiply with each recurrence, and may result in dementia.

The *petit mal*, or mild form, is betrayed in tremors, spasms of the muscles, for example, of a single limb, or of the neck, or of one shoulder ; dyspnœa, dysphagia, or vertigo. Other patients experience sudden loss of memory, or imperception of environment, confusion of ideation, and incoherence of speech.

Paraplegia is, in more than fifty per cent. of all cases occurring in male patients under forty years of age, of syphilitic origin. Over ninety per cent. of cases of syphilitic paraplegia occur in males. There may be precedent cephalalgia of extreme violence, rachialgia, neuralgia, convulsive seizures of the muscles of the lower extremities, and hyperæsthesia or anæsthesia of the cutaneous surface. The paraplegia may be partial or complete, and sudden or gradual as to occurrence, but, as Althaus indicates, is unaccompanied by loss of consciousness, the patient often "assisting" at the invasion. It is apt to terminate in complete loss of power of both lower extremities, with and without sensory disturbances, partial paralysis of rectum and bladder, and complete impotence, lasting often for years. One side of the body may be involved after the other ; or the same side may be again affected after an interval of months has elapsed. Paralysis of cranial nerves, mental hebetude, mydriasis, and other signs of syphilis of the nervous system may be present, but are often absent ; and when the paraplegia is complete this may be the sole objective symptom of the infective disease.

The occurrence of *locomotor ataxia* in syphilis is both asserted and denied by observers. The author's experience is in accord with that of Messrs. Bumstead and Taylor, who are unable to recognize in the syphilitic affections of the cord, the well-defined sclerosis of the posterior columns which is characteristic of progressive spinal ataxia. The clinical symptoms of syphilitic changes in the cord may, for a brief time, simulate those of locomotor ataxia, but the results—not merely in well-treated, but in unrecognized and therefore wholly untreated cases of syphilis—are widely separated from the remediless sequelæ of the non-specific disease.

Fournier, Erb, and Althaus have advanced strong reasons in favor of the syphilitic origin of tabes, which have been offset by the statistical facts cited by Oppenheim and others. The classical features of the last-named disease are not only not exhibited by the syphilitic patient, but specific treatment, as even Fournier admits, has not succeeded in procuring relief for the ataxic "syphilitic" patient. Pathologically, it is known that syphilis rarely selects a definitely limited portion of the cord for its manifestations, but involves here and there a patch in the columns, near which can commonly be recognized altered vessels or investing membranes where the morbid process originated.

Symptoms resembling those of *general paralysis of the insane* (*délire de grandeurs*, etc.) have been recognized in a very few syphilitic patients (Dreer), but with relation to syphilis they may be relegated to much the same position as those observed in locomotor ataxia. There is a suggestive doubt as to whether the few patients affected with general paralysis, who have, at some remote period in the past, admitted the occurrence of "a chancre," really had syphilis, and as a result of this last-named disease the progressive symptoms of general paralysis.

Jullien aptly calls attention to the striking fact that the syphilitic patient supposed to have general paralysis is really ill (cachectic, anæmic, or adynamic), while the "real fool," on the contrary, exhibiting moral decrepitude, stupid facial expression, and perturbed cerebration, appears to be otherwise in good physical health. The former, moreover, is apt to display one or more of the syphilitic paralyses following a characteristic vertigo, hemicrania, or a cephalalgia, or some one of the ocular or aural complications of syphilis, in brief, at capriciously selected points where nervous symptoms are displayed. This also is associated with a milder exaltation of ideas, and a more rapid evolution of symptoms.

Other symptoms of nervous syphilis are exhibited in gastro-intestinal derangements (vomiting, etc.) ; functional disturbances of the kidneys and bladder ; and disorders of other viscera.

Coma, preceded by cephalalgia, anæsthesia, mental hebetude, or aphasic symptoms, may occur during sleep, or result from sudden diurnal accidents. The patient is usually found lying listless, or apparently asleep, pallid, expressionless, and not suffering pain. He may be roused to take food or drink, to thrust out the tongue, or even momentarily to recognize a friend or answer a question. The pupils are usually small, insensitive to the light, and covered by the lids. The globes are shrunken in the orbits. Sensibility and reflex excitability are either wholly preserved, impaired, or lost. The pulse and respiration are retarded in frequency ; the temperature is subnormal ; the excretions are passed unconsciously.

The pathology of these several complications of syphilis is explained chiefly in post-mortem examinations.

The cranial and other bones, when involved in an oste

itis or periosteitis (diffuse, circumscribed, gummatous), may produce nodes capable of explaining etiologically several of the groups of symptoms described above by pressure effects, including inflammation and even destruction of the parts invaded. Nodes of the internal tables of the cranial vault or of the vertebræ may thus be responsible for mental, paretic, paralytic, convulsive, neuralgic, and ataxic symptoms of the most varied character. The author is inclined to believe, after observation of typical cases, that well-defined cranial nodes in the outer table also of the skull are, as the result of sympathetic influences, capable of producing many of the milder symptoms of nervous syphilis.

The meninges of the brain (dura mater, arachnoid, pia mater) are subject to the same involvement. They may be changed by pressure of a node, and be agglutinated to it; or may be separately involved in diffuse or circumscribed, single or multiple thickenings, due to proliferation and vascularization of the tissues (pachymeningitis). The lesions may be symmetrical or asymmetrical, and involve the brain more often than the cord. These changes are capable in various degrees of producing cephalalgia; and at times a distinct area of meningeal surface may be recognized as the seat of the severe headache of syphilis, with intense nocturnal exacerbation, by pressure or percussion with the finger over a limited region of the skull —a manœuvre which decidedly increases the pain.

The brain and medulla are always involved as a sequence of changes either in the bones, meninges, or vessels in anatomical relation with those organs. The softening which results may be either of the red or white forms of ramollissement recognized in non-syphilitic cerebral disease. Gummata of the brain are recognized as single, or usually multiple, occasionally exceedingly numerous, circumscribed or diffuse, superficial or deep tumors, from the size of a millet-seed to that of a small egg. They most often exist as superficial lesions in direct association with gummatous changes in the meninges. They have a well-defined yellowish or whitish cheesy centre, with a firm, sclerotic, peripheral mass set in vascularized and greatly softened nervous tissue. Evidences of simple inflammation in the brain-substance, excited by the irritating presence of the neoplasm, are usually to be recognized, and are described by Jullien as distinctive marks of a cerebral syphiloma, inasmuch as the brain-substance tolerates with greater ease the softer nodules of tuberculosis. The deep-set lesions are much rarer, but are recognized, for example, in the substance of one ventricle, in the optic thalamus, the corpus striatum, or the white substance of the cord.

The arterial changes, responsible for so many of the nervous complications of syphilis, are of frequent occurrence, and may be primary or consecutive in order—that is, they may be the original and immediate cause of cerebral disease, or the sequence of changes induced by a neighboring gumma or pachymeningitis. Heubner, Greenfield, Hutchinson, Dowse, Dreschfeld, and others, have chiefly contributed to the present knowledge of this interesting subject. The small arteries are most often attacked, symmetrically at times as regards the two halves of the brain, in distinctly limited areas, where whitish points or nodules become visible to the naked eye. Longitudinal section of vessels thus implicated reveals an obliteration wholly or in part of the lumen of the vascular tube, due to thickening of the inner coat; the middle, clearly defined, being scarcely affected (endarteritis obliterans). The adventitia is doubled or trebled in volume, its cells under the microscope being exhibited as long, parallel, fusiform elements. The obliteration of the lumen, however, is chiefly due to a cellular proliferation between the endothelial lining of the vessel and the fenestrated membrane, resembling a granuloma in appearance. Externally and internally are flattened or fusiform cells, arranged more or less regularly in parallel lines, between which are more irregularly and loosely packed larger cells, mingled with minute fibres of elastic tissue and the vasa vasorum. The endothelium is then finally separated from the membrana fenestrata, and projects into the lumen of the vessel as a vegetation, occasionally forming a second fenestrated membrane on the sides of the vessel-wall. In this way complete stenosis of the tube is eventually produced—an accident rare in atheroma, in which the cellular proliferation is more indolent, more generalized, more disposed to terminate by calcification, and never results in complete obliteration. These accidents are often the causes of the severe headache, vertigo, chorea, epilepsy, and other of the nervous phenomena noted above.

It is by the production of thrombosis or cerebral ischæmia that the arterial stenosis operates to induce the derangement.

A syphilitic periarteritis is described by a few authors (Charcot, Rabot, Bumstead and Taylor), in which circumscribed, lenticular, whitish masses of irregular shape result from an endarteritis affecting the external coats of the vessel, with proliferation also of the media and internal coat. The internal elastic tissue is reported intact, with round-celled infiltration of the muscular layer, and multiplication and dilatation of the vasa vasorum.

The cerebro-spinal nerves may suffer compression by an osseous or meningeal lesion of syphilis sufficient to produce a series of symptoms ranging from formication, hyperæsthesia, and moderate numbness, to complete anæsthesia, analgesia (rare), or paralysis. The derangements of vision induced by syphilitic changes in the optic nerves supplying the muscles that move the globe of the eye have been already considered. In a similar way, the olfactory, sympathetic, and other nerves may be implicated. Petrow, in the cases examined by him where the sympathetic nervous trunks were involved, recognized a pigmentation of the cellular protoplasm, attributed to the deposit of hæmatine in the nervous cells. The endothelial elements were proliferating and surrounded by polygonal nucleated cells, some undergoing colloid metamorphosis. These nervous elements were compressed by an hyperplastic connective-tissue growth, undergoing later sclerosis, and eventually starving the nervous elements into atrophy. The membranous envelope of the latter, after undergoing hypertrophy, may be the seat of fatty metamorphosis.

The treatment of the nervous complications of syphilis is that of the disease in general. The credit of employing large and progressively larger doses of the iodide of potassium in all serious emergencies, with brilliant results, is largely due to American practitioners. The best and simplest way of attaining the end is to administer drop doses of a saturated aqueous solution of the potassic iodide in milk every four hours, beginning with a relatively small dose, five to ten drops (0.33–0.66), and pushing on by increasing one drop each dose until the end in view is reached. By this means the author has, in exceptional cases, given one ounce and a half (48.00) of the iodide in twenty-four hours, with happy effect; and still larger doses have been reached by others. The rule should be to stop the increase at once on the supervention of any toxic effects or marked symptoms of physical protest against the large dose; to then hold at a given point, or to reduce the dose to a point of complete toleration, and to recognize the fact that after the extreme point of toleration has been fully reached, perhaps slightly surpassed, and for a moderate length of time held, further medication of this sort, in the absence of the definite and brilliant results usually attained by its adoption, is useless, and in cases harmful. It should not be forgotten, also, that in the absence of such desired results, mercury in full doses (*e.g.*, calomel one-tenth of a grain (0.0066), every hour or two in any serious emergency) may prove of inestimable value.

The prognosis in syphilis of the nervous system, even in the face of apparently desperate peril, is far more favorable than in the case of nervous symptoms of similar import occurring in those who are not the victims of that disease.

Muscles, Tendons, and Articulations.—Muscular contracture is described by a number of authors as a syphilitic accident occurring slowly or rapidly, and producing fixed flexion or extension of any movable part to which the tendon of the muscle is attached, the latter, on

palpation, being recognized as a rigid and inflexible cord. The joints are not in such cases involved. One or several muscles may be attacked, the biceps being that most commonly affected, the forearm being then flexed at an acute angle upon the arm. The involved muscle may and may not be then the seat of pain and tenderness. A tetaniform involvement of a much larger number of muscles is described also by writers as of occurrence in syphilis.

In the diffuse form of myositis occurring in syphilis, there is diffuse swelling of the whole or a part of a muscle, some redness and œdema of the overlying skin, and pain when the muscular fibres contract. Gummata of the muscles are small, at first firm, later softish, usually globular masses, from the size of a nut to that of an egg, of insidious development, and often, when in process of disintegration, attached to the skin and undergoing the cycle of changes already described in connection with the ulcer resulting from subcutaneous gummata. It is believed that the sheaths of the muscle-bundles are first involved in these changes. They undergo, in some instances, osseous and cartilaginous metamorphoses instead of disintegrating.

The tendons, tendinous sheaths, and aponeuroses may become in syphilis the seat of flattish, triangular, circumscribed, and usually painless tumors, due to effusion in the serous sacs; or to projecting gummata which may break down and ulcerate, leaving a cicatrix whose contraction may subsequently interfere with the function of the muscle to which such a tendon or aponeurosis is attached. Diffuse gummatous thickenings also affect the fasciæ and aponeuroses, more particularly those of the lower extremities.

The bursæ are not rarely affected in tertiary syphilis, more particularly those of the patella and of the tibial tuberosity in women. They begin as single, painless or slightly painful, firm, elastic, or softish gummata, from the size of a nut to that of an egg, which are apt to involve the skin eventually, and to be obstinate under treatment. The author has now in hospital a woman, twenty-five years of age, with the ligament of the left patella fully exposed at the bottom of an ulcer, as large as the palm of the hand, and involving all the neighboring parts, which began as a gummatous bursitis.

Syphilitic rheumatism (arthralgia, pseudo-rheumatism) may be an acute, more often a subacute, polyarthritis with tender and painful points about the articulations, preceded often for days by arthritic pains, as distinguished from simple rheumatism. This complication is remarkable for the failure of acuity in the symptoms, the relative painlessness of the affected joints, the absence of articular swellings (*arthritis sine materia*), and the nocturnal exacerbation of the pain. Hydrarthrosis, most commonly symmetrical and of the knee-joints, though also mono-articular, is both an early and a late symptom of syphilis, and is chiefly remarkable for the extent to which the joints may be distended with synovial fluid, and be yet sufficiently free from pain to permit of performance of their function. It often recurs and disappears for several weeks at a time. The so-called "syphilitic white swelling" is due to fibrous thickenings and subsynovial, gummatous infiltrations in and about the joint. In the author's experience, these synovial effusions have occurred only in the subjects of cachexia, or young male patients of fragile constitution.

The fingers and toes may be the seat of primary, secondary, and tertiary syphilitic lesions, and in both acquired and inherited syphilis. To Dr. R. W. Taylor's exhaustive researches we are greatly indebted for a knowledge of this interesting subject, to which merely a brief reference can be made in these pages.

The affection is more common in hereditary than in acquired disease. In the former the disease may begin in the subcutaneous connective and fibrous articular tissues, or primarily in the osseous and periosteal tissues, and consecutively invade the other structures named. The digit affected, either in one or more phalanges, enlarges insidiously, becomes dense, painful, inflexible, with attached overlying and purplish-red skin. Sometimes an articular hydrarthrosis can be detected; again, one or more of the symptoms resulting from gummatous infiltration. These gummatous deposits are circumscribed or diffuse, and not prone to ulcerative degeneration. Specific dactylitic osteo-myelitis, periosteitis, or osteo-periosteitis, may be a slow, rapid, or relapsing accident, producing in full evolution a balloon- or acorn-shaped, globular, or pyriform swelling, involving one or several phalanges of a single digit, usually the proximal, and more often those of the fingers than of the toes. As sequelæ, may be enumerated inflammatory changes with abscesses discharging a caseous matter, crepitation from roughness of the articular faces of the cartilages, the formation of sinuses, hydrarthrosis, and osseous atrophy after resorption of the gummatous deposit, leaving the shaft of the phalanx more slender and fragile than before. In other yet more marked cases, two conspicuous instances of which were lately exhibited at the author's clinic, the phalanx is reduced by shrinkage till the finger is shortened one-third or one-fourth of its length. The resulting deformity is conspicuous, and almost peculiar to the special disease under consideration.

Cartilages and bones are attacked in both early and late forms of the disease. The most common form of bone disease is an osteo-periosteitis characterized by inflammatory phenomena, vascularization, and exudation, diffuse or circumscribed, of the area of contact of the osseous and periosteal surfaces. The result is declared in the formation of well-defined, rarely poorly circumscribed nodosities in various degrees sensitive, and usually the seat of a characteristic pain, intensely, often intolerably, aggravated at night after retiring to bed. Absorption may result or, much more rarely, degeneration and exfoliation of a thin lamella of bone. In other cases an exostosis results from a plastic effusion between the periosteum and bone, usually circumscribed and flattish, globoid, annular, sessile, or pedunculated, which may undergo eburnation and exhibit compact or cancellated tissue in its structure. When the bone has been infiltrated with a gummatous material which degenerates, it is usually the epiphysis which is the seat of the disorder, though the medulla (osteo-myelitis) and bony substance, or even periosteum and bone, may be involved. Ulceration may then leave a roundish cavity, from the size of a pea to that of a nut, possibly communicating with the medullary canal, filled with a bright-yellowish pulp; the faces of the cartilages become the seat of salient granulations and depressions (scars ?), the size of millet-seeds. At times the diaphysis of the bone is first attacked and the epiphysis secondarily. Often the synovial membrane remains intact.

The "dry caries" or "inflammatory atrophy" of Virchow is a change beginning with vascularization, but unaccompanied by suppuration or ulceration, in which the osseous substance is found wanting in stellate or foveolated pits which may enlarge in the line of furrows representing the Haversian canals. These parts are surrounded by hyperostosis. Bumstead and Taylor look upon these and similar depressions in the osseous substances, when osteoid growth has ceased centrally and is actively progressing at the periphery, as syphilitic cicatrices of bone. The meninges, periosteum, and integument may participate in the formation of such cicatrices, resulting finally in the production of a uniform, thin, contractured, whitish or grayish fibrous tissue, unprovided with vessels.

The various bones of the skeleton are in different degrees subject to the several changes described above. The vault of the cranium is particularly liable, in both external and internal tables, to exhibit single or multiple, circumscribed osseous changes, as also are the sternum, the clavicle, the ribs, and particularly the tibiæ. The substernal and similar pains, noted so frequently as precocious phenomena in the early periods of the disease, are probably associated with transitory osteo-periosteal hyperæmia. In the later periods the nodes that form, whether inflammatory or gummatous in type, are characterized by the same severe nocturnal exaggeration of the pain they excite, and by marked localized tenderness. Some of

the consequences resulting from the pressure induced by intracranial nodes have been described in the paragraphs devoted to the phenomena of nervous syphilis. Gummata of the frontal and temporal bones, forming firm projecting tumors, are at times so conspicuous as to produce marked deformity. Other bones besides those named, *e.g.*, the radius, ulna, femur, maxillary, and, indeed, any part of the skeleton, may become the seat of these lesions. The treatment is that of syphilis in general, more particularly in its tertiary stage. The remarkable effect of the potassic iodide upon many of these lesions is one of the demonstrations, which even the most sceptical are compelled to accept, of the signal efficacy of an ingested drug upon a neoplasm defying local therapy. The dose is to be pushed, to secure marked relief, to any required point precisely as indicated above in the management of nervous symptoms. Indeed, as will be gathered from what has preceded, the same treatment is often urgently demanded in the same patient, at the same moment, for relief of grave nervous complications depending solely upon syphilitic osseous disease. Locally, the mercurial ointments, plasters, and oleates, with occasional use of anodynes, fill an important part.

Hereditary Syphilis.—This form of the disease, the only one not known to originate by an initial sclerosis, is also termed congenital and infantile syphilis. The syphilis of infants, acquired by accidental or intentional transmission after birth, is practically that of acquired syphilis of adults, the differences being chiefly due to the tender skin of the young patient and its extreme liability to nutritional disorders.

Hereditary syphilis is the disease transmitted by inheritance from one or both progenitors to a second generation. Evidences of such transmission to the third generation are extremely rare. The more active the disease in the progenitors, the greater the chances of infection of the offspring.

In inherited, no less than in acquired, syphilis pathologists have recognized micro-organisms which have been claimed to be effective in the evolution of the disease. Doutrelepont, Kassowitz, Hochsinger, Kalisko, and Chatzen have both detected and failed to detect streptococci in the viscera of children affected with hereditary lues, more particularly in the skin, mucous surfaces, bones, and liver. In some instances the lymph-channels have been found choked with micro-organisms of this kind, which fact has suggested to Chatzen that the cachexia of some patients in this category was a streptococcus-septicæmia.

Relative Influence of the Parents in the Transmission of the Disease.—The father alone, when the victim of an active constitutional syphilis, is capable of transmitting the disease to his child without infection of the mother. It is probable that he does not possess this power before the disease is actively displayed in his own person by constitutional symptoms. It is certain that this power is greatly weakened while he is under the influence of mercury; is weakened and regained during the respective periods of repose and activity so commonly observed in the disease; and is finally extinguished by time. It remains to be admitted that the cases in which the father alone is thus responsible for syphilis in the second generation are far fewer than those in which the mother alone is thus responsible; and that the power of such transmissibility is positively denied to the father by the followers of Cullerier, Oewre, and others.

The mother alone, the father being unaffected, may transmit syphilis to the child, if she be the victim of an active constitutional disease. If conception occur later than the twentieth day after the appearance of the earliest syphiloderm, the product of such conception is almost certainly doomed to destruction, abortion of the ovum commonly following from the third to the seventh month. The woman, however, profoundly syphilitic, may abort or miscarry in consequence of the cachectic state to which she is reduced by syphilis, and may thus throw off, as in any cachectic condition, the unaffected germ. Again, the child may escape entirely by the operation of that inscrutable law which ever and again protects the offspring from the vices and errors of the parents. Lastly, in a series of pregnancies, abortions may be followed by miscarriages; the latter by stillbirths at term; then by viable infants exhibiting symptoms of syphilis before the fourth month of life; and, lastly, by the birth of children in whom syphilis can never be recognized, the power of transmission being weakened till it is wholly lost in the process of time.

If the mother be affected after conception, it is probable that she cannot convey her disease to the child. She may abort or miscarry in consequence of the anæmia induced by her own disease, but it is improbable that, either in the first or latter half of pregnancy (both periods have been claimed as those of special danger), the virus can be transmitted through the utero-placental circulation. Cases have been cited in support of both views as to the possibility and impossibility of such transmission, the cases cited in support of the affirmative view being in the main defective, by reason of failure to demonstrate both perfect immunity of the father and positive syphilis of the child.

A healthy mother may bear a syphilitic child. On this point also there has been much division of authority. The large number of all mothers who bear syphilitic children are themselves unquestionably syphilitic. But the possibility that a syphilitic child may be infected by inheritance from the father alone, the mother remaining sound (precisely as is the case when the child is sound and the mother healthy), is demonstrated by numerous facts. Dr. Taylor, of New York, and the author have in this country substantiated by reported cases the facts set forth abroad by Kassowitz and others. The well-known law of Colles is urged in support of such transmission. That law formulates a well-known clinical fact, viz., that the mother of a syphilitic child is never infected at the breast by her offspring—the secretions of whose diseased mouth are infective for all healthy persons. A few exceptions are reported to this law, so few and so inconclusive as to rather more fully establish its general applicability. It is probable that the system of the mother, after the bearing of such children, is so modified as to render her incapable of receiving the disease. If the sound child be infected at the moment of birth by direct contact with recently developed, secreting, primary, or secondary lesions existing upon any part of the external genitals of the mother (an accident reported in a few cases), the result is acquired infantile, and not inherited, syphilis.

The clinical symptoms of hereditary syphilis are first the death of ovum or fœtus. These products of conception are then ushered into the world either undistinguishable from the dead products of pregnancies where no syphilis has interfered; or macerated, the epidermis being readily separable from the corium, which is deeply congested, or, for the reason first named, raised into bullæ, and the viscera in various ways are profoundly altered. In a second list are to be classed stillbirths, and the birth of children surviving but a brief time. These may be apparently unaffected by disease; or covered, in various degrees, with bullous lesions produced by passive exudation of fluids elevating the loosened epidermis from the corium; or suffer from visceral changes. In a third category may be named children who survive for various periods to maturity. One-third of all are thought, however, to perish without attaining that development. Many perish before the second month; those who survive commonly exhibit the symptoms of inherited syphilis in the same period, even if no signs are apparent at birth. Hereditary syphilis is rarely deferred in its manifestations after the fourth month. Cases reported as of late inherited syphilis, where the first symptoms of that disease were manifested at the period of puberty, for example, are regarded by most experts with suspicion.

The *placenta* may be the seat of a diffuse or circumscribed gummatous infiltration. The two may concur. In such cases the syphiloma is characterized as usual by the firm, external, fibrous, grayish-tinted layers surrounding a softer, yellowish central mass. Hydramnios is

also counted among the possible syphilitic changes of pregnancy.

The skin of the victim of inherited syphilis is subject to many changes resembling, for the most part, those recognized in the acquired form of the disease. It is commonly seen to be either flaccid and wrinkled, or tightly stretched over the bones as if deprived of its panniculus adiposus. In this way the characteristic little-old-man and little-old-woman appearance of the syphilitic infant is produced. The skin has, moreover, a not less constant and characteristic sallow, yellowish, earthy hue. Manifestly the nutrition is profoundly impaired, and the child exhibits a series of symptoms, such as vomiting, diarrhœa, etc., which indicate that not the skin alone but other organs are participating in the disease. As a matter of practical moment, it is well for the practitioner to remember that a healthy-looking, well-nourished child, six months and more of age, without pulmonary or gastro-intestinal disorder and no signs of disease save a suspicious-looking eruption upon the skin, is probably *not* the victim of inherited syphilis.

The macular or erythematous rash (roseola) appears usually over the belly, face, neck, palms, extremities, and other parts, in the form of roundish or oval-shaped macules, from the size of a split pea to that of the finger-nail, of the copper-and-reddish shade, soon refusing to yield under pressure, often seen as the earliest cutaneous symptom of the disease. The spots may enlarge by multiplication or coalescence ; may, in cases, become elevated or covered with scales ; or may undergo fissure.

Papules, mucous plaques, mucous patches (of the skin and mucous membranes), and condylomata lata are all phases of one and the same process of proliferation in hereditary syphilis. The most common of all is the occurrence of these flattened papules or patches in the nasal cavity, furnishing a serous discharge which rapidly becomes purulent or hæmorrhagic in type, and which by desiccation soon blocks up with crusts the nasal passages. As a consequence a characteristic "snuffles" follows, the child abandoning the nipple to get breath, and even in sleep uttering a diagnostic snore. On many occasions physicians, hearing this suspicious respiratory sound in infants brought to them for relief of cutaneous ailments, have thus obtained a clew to the real nature of the malady. Specific coryzas of this sort may progress to ulceration or osseous necrosis. Similar roundish or oval-shaped patches, or (after confluence) large sheets of involved mucous surface, may be recognized in the mouth, furnishing a highly contagious secretion. In this way the tongue, lips, gums, and fauces may be involved, and the child may be rendered incapable of seizing the nipple with the mouth. At the angles of the mouth, also, on the muco-cutaneous surface, flat papules, condylomata, or secreting patches may conceal the natural outlines of the parts, be extensively crust-covered, or even superficially or deeply ulcerated.

Over the general surface of the body, small or large, flat or, more rarely, acuminate papules, copper-colored and reddish in hue ; smooth or scaling, symmetrical, and generalized or limited to a single region, may be conspicuous. They may coalesce, furnish a patch of infiltration, and even extensively ulcerate. The most frequent manifestations of this type, next to the nasal lesions accompanied by "snuffles," are the condylomata about the anus, from the size of a pea to that of an egg and larger, flattened, whitish or reddish lesions, secreting, elevated, and distinctly circumscribed.

Vesicles, isolated or confluent, conical or flattened, from the size of a pin-head to that of a split-pea, may also spring from macules or papules, rest upon a brownish and reddish base, and be filled with serum or a sero-purulent fluid. They are rare lesions. Pustules, from the size of a pin-head to that of a split-pea, are more often seen, with and without a previous or concurrent evolution of vesicles or papules ; often as a metamorphosis of the latter. The skin thus affected is commonly infiltrated, purplish, and covered with brownish or greenish crusts. Beneath these may be simply excoriation or ulceration. The genital region, face, scalp, and lower extremities may be involved ; rarely the entire surface of the body. The scarring which results is not conspicuous.

Bullæ are grave and unfortunately common symptoms of inherited syphilis. They may, as indicated above, be conspicuous at birth, single or multiple as to number ; or develop later as wine-colored, circumscribed patches of integument ; first pea-sized, later as large as an egg, an orange, or a cocoa-nut, filled with serous, lactescent, or hæmorrhagic contents. The palms and soles are frequently involved. The areola is violaceous, often infiltrated and raised. The brownish crusts cover ulcers with a foul, hæmorrhagic, or diphtheritic floor. Death usually ensues, when the eruption is at all generalized, in the course of a few days. Furuncles, beginning as circumscribed cutaneous or subcutaneous and indolent nodules, from the size of a pea to that of a nut, may be in some cases so numerous as to constitute a characteristic and even symmetrical eruption. They may, after a typical suppuration, discharge a core by sloughing, or break down into conical ulcers of the crateriform shape.

Tubercles and gummata may observe almost the same cycle. They also begin as roundish or irregularly knobbed, usually subcutaneous nodules, which break down, furnish an irritating, semi-purulent or serous discharge, and finally result in ulcers of the typical aspect already described as of occurrence in the acquired forms of syphilis. These ulcers may also follow the less circumscribed gummatous infiltrations of the skin and subcutaneous tissues.

Many of the grave cases of profound destruction of tissues about the face (eyes, nose, lips, jaws, etc.), illustrated in the works of the best authors on the subject of hereditary syphilis, originated in gummata whose ulcerative processes, beginning in or beneath the skin, spread thence to muscles, fascia, periosteum, and bone.

The *larynx, trachea,* and *neighboring parts* may be, in early inherited disease, the seat of ulcerations resulting in the production of stenosis, cicatrization, and bridles stretched between adjacent walls, so as to interfere with the function of the organ implicated. The late forms are described by Fournier as diffuse hyperplastic, circumscribed gummatous, and sclero-gummatous—the last-named a combination of other forms. These may be serious in consequence of the results recognized in acquired disease, viz., production of (chiefly laryngeal) dyspnœa, glottic spasm, acute œdema, and sudden death. Sclerosed masses, subsequently exhibiting a central yellow softening, have been recognized by Lebert and others in the lungs of children dead of inherited syphilis, which are believed to be gummata of these organs.

The mucous lining of the *alimentary canal* may be the seat of changes similar to those observed in the exposed mucous surfaces of the subjects of the disease. Circumscribed hyperæmia and even indurated hyperplastic, as well as ulcerative, patches have been recognized about the solitary and agminated glands. The liver may be, after the occurrence of specific changes in the walls of its vessels, hypertrophied, dense, and resisting ; or the seat of pedunculated tumors, or of diffuse or circumscribed parenchymatous gummata. These may be miliary or nut-sized, and surrounded by the usual fibro plastic envelope. The spleen is probably always involved in the child affected with inherited syphilis. It may be the seat of a partial or general perisplenitis, capsular or subcapsular in situation ; is always greatly increased in size and weight ; and may undergo later, under treatment, reduction to its normal size, or, in other cases, lardaceous metamorphosis. The increase in size and weight which has been noticed in the pancreas is different, in that it seems to be accompanied by a sclerosis due to hypertrophy of the interstitial connective tissue.

The *suprarenal capsules* may be involved in a partial or complete peri-capsulitis ; as also in a parenchymatous deposit of miliary gummata. Fatty, colloid, and gelatiniform degeneration may be observed as a result of these morbid changes in both capsule and substance proper. The *kidney* has been found enlarged and also containing one or many miliary, whitish or yellowish, circumscribed gummata, or diffuse infiltrations. The

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origin of these lesions has been traced to proliferative changes in the connective-tissue stroma of the organ. Here, too, colloid and fatty degeneration has ensued—in rare cases, ulcerative destruction. One or both *testes* may be involved in male patients, the disorder beginning with an indolent tumefaction of the testis proper (the epididymis being usually spared), smooth, lobulated, and accompanied or not by moderate hydrocele and scrotal engorgement. Fournier calls attention to the discovery, in patients exhibiting tardy symptoms of inherited disease, of small, densely indurated testicles, either arrested in development or the fruit of the gummatous changes wrought in earlier periods of the disease. It is possible that the ovaries may be similarly involved (Panot).

The *hair* and *nails* are affected in hereditary as in acquired syphilis, chiefly after involvement of the tissues on which they depend for nutrition and support. In this way patches of alopecia become visible in the scalp. The nails are surrounded by a ring of purplish infiltration; or papulo-pustules, degenerating into ulcers, undermine the matrix and possibly finish with loss of the nail and formation of a cicatrix. The deformity of the distal phalanx in these cases is strikingly characteristic, presenting as it does a livid club-like enlargement, often both tender and painful, bearing, usually on one side only, a semilunar ulcer with sero-purulent secretion, foul base, and distorted or displaced nail. The nail-substance in these cases may be friable, eroded, "worm-eaten" in appearance, frayed, or laterally ridged and furrowed.

The changes so strikingly characteristic of inherited syphilis in the *eye* (keratitis, etc.), *ear* (remediless deafness of late inherited syphilis), and *teeth* (Hutchinson's changes), have already been described. A group of symptoms less classical and constant are puriform depots in the *thymus gland*, supposed to be abscesses (Dubois); glandular abscesses due to the irritation of neighboring cutaneous lesions (*e.g.*, in the neck, when associated with scalp or mouth disease); hæmophilia, or hæmorrhagic symptoms appreciable at birth or soon after, in the cutaneous or mucous surfaces, probably due in greater measure to the cachexia of the disease than to specific changes; stenosis of veins and arteries (perhaps associated with gummatous changes in the vascular wall similiar to those occurring in the endarteritis obliterans of acquired syphilis); and fusiform swellings of the synovial sheaths over the metacarpal bones (Bumstead and Taylor).

The affections of the *bones* in hereditary syphilis have been exhaustively studied in the last decade by Wegner, Waldeyer, Parrot, Taylor, Fournier, and others. They are among the most common of all the symptoms of the disease, being next in order to the ocular changes. All the phenomena long ascribed to rickets are to-day referred to inherited syphilis. Osteochondritis usually affects the diaphyso-epiphyseal extremity of the forearm, leg, arm, or thigh, but all the bones may be involved in the newlyborn infant, and that as the sole manifestation of the disease, or in conjunction with skin and other lesions. A partial or complete annular swelling, smooth, or irregular, or ridged, is then found, of insidious or rapid development, encircling the extremity of the bone (distal extremity of ulna, sternal extremity of clavicle). There may be articular effusions in the contiguous joint. The swelling may disappear under treatment, or degenerate by ulceration as in gummata, resulting in loosening, separation, or destruction of the epiphysis or cartilage; or ultimately result in death by exhaustion. The bone may be shortened as a result, or invested with a thickened periosteum. The pathological changes may be described briefly as due to proliferation of the cartilage cells, with mamelonation of the epiphyseal surface, and calcification of the osteoid processes. Periosteal and perichondrial thickenings follow, conjointly with retarded osteogenesis at some points.

Osteoperiosteitis is a later bone symptom of inherited syphilis, affecting predominantly the tibia, but also the ulna, radius, cranial, and other bones, often more than one bone in one subject of the disease, and then at times symmetrically. The hyperostosis resulting may distort the tibia so as to produce the so-called "sabre-blade" deformity, its voluminous mass forming a curve, with an anterior or lateral convexity, painful, tender, and indolent of development; or it may result in characteristic multiple cranial hyperostoses of the temporal and frontal regions. All these forms may result in necrosis, ulceration of bone, and formation of fistulous tracts through which sequestra may be removed.

In gummatous osteomyelitis the medullary canal, after degeneration of a gummatous infiltration, may be the seat of a cheesy tissue here and there enclosing solid masses, surrounded by layers of newly formed bone.

The syphilitic dactylitis of inherited resembles that of acquired, disease, the swellings attacking slowly or rapidly, with or without pain, one or more of the proximal phalanges, or metacarpal or metatarsal bones. In all these bone lesions the joints may participate secondarily, or the synovial membrane or fibrous capsule may be first to induce a hydrarthrosis or tumefaction, which may go on to degenerative changes involving cartilage and bone, or be averted at any stage by treatment.

The *nervous system*, in inherited syphilis, is chiefly involved after the occurrence of structural changes in the meninges and other neighboring parts. Fibrous and gummatous thickenings and infiltrations, diffuse and circumscribed, may implicate one or more of the meningeal layers, agglutinating them to each other or to the nervous structures they enclose. Periosteitis of the surfaces in contact with these membranes, intracephalic scleroses and gummata, and occlusions of the lumen of the cerebral vessels, may here, as in acquired disease, be followed by a long series of nervous symptoms, dilatation of the pupil, facial paralysis, paraplegia, hemiplegia, epileptiform seizures, hydrocephalus, idiocy, and various grades of failure of intellectual development and vigor. Fournier, in describing the late forms of this complication, lays stress upon the occurrence of severe and persistent cephalalgias, similar to those so frequently recognized in acquired syphilis of the nervous system. The same author believes that there is an heredito-syphilitic tabes, and possibly also a sclerosis *en plaques*. The paralyses resulting from compression or other changes in the nervous trunk chiefly involve the ocular muscles.

The *treatment* of the mother affected with syphilis, and pregnant or nursing a syphilitic infant, is usually indicated. Mercurial inunction of the infant by smearing its flannel roller with oleates and salves, is an efficient means of introducing the metal when it is required. Calomel, or the gray powder, may be given, one grain to one-twentieth of either (0.066 to 0.0033) rubbed up with sugar of milk, and placed upon the tongue of the infant, three or four times daily. The dose can be nicely adjusted to the requirements of each case. The bichloride may be substituted in combination with syrup of licorice or of ginger. Ten drops may be given of a two-ounce (64.0) solution, containing from one-fourth to one grain (0.0160 to 0.66) of the sublimate to the ounce (32.0). Inunction is, however, far preferable for the majority of cases, with the administration of cod-liver oil by the mouth. When mercury and the iodide of potassium are both indicated (more particularly in the management of osseous lesions), the several combinations known as the syrup of Gibert are useful, *e.g.*:

℞.	Hydrarg. biniodid	gr. j.	(0.66)
	Potass iodid	℥ ss.	(16.0)
	Syr. glycyrrhiz. (vel zingiber.),		
	Aq. dest	āā ℥ ij.	(64.0)
M.			

Of this solution the infant under the fourth month can take from five to ten drops in water, the larger dose being gradually reached. Similarly, in all portentous cases, the iodide of potassium may be administered in drop-doses of a saturated solution to the point required to produce any desired effect, as already described in the treatment of nervous syphilis in the acquired form. In all cases the diet and hygiene are highly important considerations. The heredito-syphilitic child should be at the breast of the mother (and at the breast of none other), if it can be thus properly nourished. The local manage-

ment of the mouth, the ano-genital region, and all syphilodermata is important, and to be conducted on principles heretofore indicated. Tonics are often useful. The prognosis is grave in all severe cases. In viable children, free from visceral complications, much can be accomplished by treatment.

TREATMENT OF SYPHILIS.—The chief point of importance in syphilis is the non-medicinal management of the patient, without a proper knowledge of which the most skilful use of drugs is ineffective. This introduces to the wide field of diet, hygiene, climate, and occupation of mind and body. The diet should be nutritious, and should exclude alcohol in all forms not specifically directed by the practitioner, with a view to securing its valuable tonic (not stimulating) effects. Tobacco in every form is best discarded, as having an injurious effect upon the nutrition in general, as well as upon the mucous surface of the mouth, which constitutes such a fertile field for the development of mucous patches. The body should be sponged daily with cool or tepid water, and then briskly scrubbed till warm, when the general surface is not the seat of syphilodermata forbidding such a course. The skin should be properly protected by woollen underwear. To the immense majority of syphilitic patients sexual indulgence should be absolutely prohibited, the few exceptions being furnished by husband and wife both convalescent from unmistakable disease. Most patients are better for regular and systematic attention to their usual occupation, though the latter should not unduly tax the mental or physical powers. The bowels should be evacuated daily. Exercise in the open air and due regulation of the hours of sleep should not be forgotten. In many cases, where the purse of the patient will permit, the recreation of travel, a sojourn at the sea-shore, or a change from an inhospitable to a mild climate, are valuable steps toward recovery.

In a small percentage of cases the expectant or tonic treatment of syphilis, conducted largely by the measures described above, aided by the use of tonics (ferruginous, bitter, acid), suffices for what seems to be a cure. Indeed, no observer of large experience can deny that cases of exceedingly mild and benignant syphilis are often untreated and exhibit no recurrence.

The immense preponderance of cases, however, is on the other side of this slender border line of safety; and the danger of such an expectant course, for most patients, is sufficiently grave almost to furnish the basis of serious charges of neglect and carelessness against the practitioner who habitually pursues it.

Mercury is to-day, as for nearly four hundred years past, counted the most efficient of all drugs in the treatment of syphilis. It is given by the mouth in the form of the protiodide, biniodide, bichloride, calomel, gray powder, blue mass, or other combinations of the metal. The protiodide is deservedly popular with American physicians, and may be given in one-fifth of a grain (centigram) granules, pellets, or disks. It is usual to begin with one after each meal, and to increase gradually till some constitutional effect is produced, such as looseness of the bowels, slightly increased flow of saliva, or moderate abdominal pain, after which the dose is reduced. Keyes suggests at this point a "tonic" dose—one which can be tolerated for months at a time without inconvenience, and reached by the reduction of the dose described above. For speedy effect, calomel is employed in doses of one-tenth of a grain (0.0066) every hour; and for slower effect, less often. It is well administered in powder rubbed up with sugar of milk. The mercurial pill has the advantage of being readily combined with iron, as *e.g.*:

℞. Pil. hydrarg.................. ℈ij. (2.66)
Mass. Vallet (pil. ferri subcarb.)...................... ℈ss. (0.66)
Opii extract.................. gr. iv. (0.26)
M. Ft. pil., No. xx. Sig.—One after meals.

The dried ferric sulphate, quinine, ergotine, and aloes, may each, when indicated, be incorporated in these or similar pills.

The bichloride is often best combined with iron in some such acid solution as:

℞. Hydrarg. bichlorid.. grs. i.–ij. (0.066–0.133)
Ferri tinct. mur.,
Acid. mur. dil....āā ʒ ij.–iv. (4.–16.)
Syr. zingiber. (vel sarzæ)............ f ℥ ij. (32.)
Aq. dest... .....ad f ℥ vj. (192.)
M. S.—A teaspoonful in a wineglassful of water after each meal.

Solutions of the bichloride effected with the aid of alcohol or with an equal quantity of the muriate of ammonium are also useful.

The biniodide is usually administered by decomposing corrosive sublimate with the potassic iodide, and dissolving the precipitate in an excess of the same salt, *e.g.*:

℞. Hydrarg. bichlorid........... gr. j. (0.066)
Potass. iodid................ ʒ ij. (8.)
Aq. dest.................... ℥ iij. (96.)
M. S.—A teaspoonful in water after meals.

The Gibert formula, modified variously by almost every author, is nearly as follows:

℞. Hydrarg. biniodid........... gr. j. (0.06)
Potass. iodid................ ʒ j. (4.)
Aq. dest.................... ʒ j. (4.)
M. Filtra, deinde adde syrup. aurant. cort................. ℥ vj. (192.)
S.—One to two teaspoonfuls in water after eating.

Combinations of mercury and the potassic iodide are employed chiefly in the so-called "mixed" treatment of syphilis; in lesions that are transitional in type between secondary and tertiary stages; and also in many precarious or rebellious symptoms in the earlier stages of the malady. Pills of the bichloride and biniodide are usually objectionable on account of their tendency to the production of irritative effects, but are in some cases given with great advantage. From one-sixteenth to one-fortieth of a grain of either (0.004 to 0.0016) may thus be administered after meals.

Mercury is of great service when applied by vapor in fumigation. This method is generally, in the larger cities of the country, relegated to the bath-houses, but by the aid of a chair, a blanket, and Lee's or Maury's lamp, it can be employed at the residence of any patient. From one to three drachms (4.–12.) of calomel, cinnabar, or the gray oxide, or two or more of them in combination, are used for the production of the vapor when placed on the metallic plate of the lamp. Steam is furnished by water boiling in the chamber designed for that purpose, and the naked and sweating skin of the patient, wrapped in the blanket over the lamp, is thus subjected two or three times a week to the fumes of the mercury.

The uncleanly, but very effective, method of introducing mercury by inunction is popular abroad, but used in this country chiefly by experts, in hospitals, and at certain springs enjoying repute for the relief of this disorder. Equal parts of the twenty per cent. mercuric oleate and scented vaseline, or the ordinary mercurial ointment, may be used, one drachm (4.) or more being rubbed at night before retiring into different portions of the skin (selecting a new region each night), and removed by a bath in the morning.

Hypodermatic injections of mercury in various forms are popular upon the Continent of Europe, but much less frequently employed in England and America. They are rapidly effective when used. They have been the subject of much favorable and adverse criticism, and even at this late hour are both praised and decried by leading syphilographers. They are subject to the disadvantage of requiring a physician for the administration of each dose, and therefore more suited to hospital than to private practice. The following formulæ have been employed: Calomel, one and one-half to three grains (0.10 to 0.266), rubbed up with about twenty-four minims (1.50) of pure glycerine (Scarenzio); corrosive sublimate,

four grains to the ounce (0.266 to 32.0) of distilled water; fifteen minims (1.00) to be injected every two or three days (Lewin). These solutions have been modified by incorporating with them one-tenth of a grain (0.0066) of the acetate or of the sulphate of morphine, to relieve pain; and the chloride of sodium, four parts to one of the bichloride, to render the solution less irritating. As these subcutaneous injections are liable to be followed by abscesses, attempts have been made in the direction of securing a soluble albuminate or peptonate of mercury, all of which have proved unsatisfactory. Solutions of the bicyanide, biniodide, nitrate, and formidate of mercury have also been recommended. None of these devices has yet rivalled in popularity the solutions of corrosive sublimate in distilled water.

When mercury produces its happiest effects in syphilis, by any mode of administration, the symptoms diminish or disappear, and the patient actually gains in weight. This has led to conclusions respecting a so-called "tonic" effect, which it is supposed by some authors to produce when properly administered. When improperly employed, it is not responsible for many of the results popularly ascribed to its influence. These are chiefly syphilitic symptoms of patients misinformed as to the nature of their disorder. The statistics collated by the physicians of the great Russian mercury mines, of disease observed among the workers in the metal, include none of the symptoms popularly ascribed to the influence of this metal in syphilitic patients—mouth patches, rheumatism, eruptive symptoms, etc. They are all in the direction of salivation, and, in grave cases, of maxillary necrosis. Tenderness of the gums, moderate fetor of the breath, slight increase in the salivary flow, noticeable indentation of the sides of the tongue by the teeth, and tumefaction of the mucous membrane—these are the first signs of a toxic effect which may increase, if the drug be further pushed, to the extreme of complete salivation, with loosening and even falling out of the teeth. In the modern treatment of syphilis no such effects are desired, or even attained. The milder of these manifestations readily disappear under appropriate therapy: tepid gargles of milk, flaxseed tea, or sweetened or demulcent water, containing one drachm (4.) of potassium chlorate to the pint (500.) of vehicle; a liquid and nutritious diet; abstinence from iced, alcoholic, spiced, acetous, and hot articles of food and drink; suspension of the mercurial; laxatives sufficient to secure complete evacuation of the bowels; and often a tonic, not containing the mineral acids.

Iodine and its compounds are useful in combination with mercury and without such union. They are more available in tertiary or late secondary symptoms, but may be often employed with the greatest advantage in the earliest symptoms of the disease. The articles of the class most used are iodine, iodoform, and the iodides of lithium, sodium, starch, and potassium. No one of these is equal in value to the iodide of potassium, or enjoys to the same degree the confidence of the profession. It may be given alone or with mercury by the mouth; or it may be given by the mouth when mercury is employed by inunction or fumigation; or it may be given in alternation with one or more of the courses named.

It is always best administered in solution, from three grains to twenty (0.26 to 1.33) given in distilled water, milk, or any other vehicle preferred, such as cinnamon water, or one of the various syrups employed as vehicles by the druggist. The method of administering the iodide of potassium in largest dose, gradually reached, from one drachm to an ounce (4.0 to 32.00) in the twenty-four hours, has been fully described in the paragraphs devoted to nervous syphilis. Employed with all due precautions it furnishes one of the most brilliantly effective of the measures at hand in the grave emergencies of the disease. When its morbid effects are produced, these may become apparent after the exhibition of the smaller doses. Among them may be named severe coryza, with œdema of the lids, lips, and glottis; salivation; gastro-intestinal distress and tenderness; and a series of cutaneous eruptions. In the order of frequency the latter are acne-form papulo-pustules; furuncular lesions; purpura; tubercles; erythematous macules; bullæ; and eczemaform patches.

An enormous number of medicinal articles, beside those named, have been used in the treatment of syphilis. Some are indispensable in the management of most cases; some have a doubtful effect; many are absolutely worthless. In the first class may be named the ferruginous tonics; the mineral acids (not to be given simultaneously with a mercurial); cod-liver oil; quinine and the vegetable bitters; alcohol, judiciously administered; and, in particular, the fluid extract of erythroxylon coca, first warmly recommended by Taylor in the management of syphilis, and fully endorsed by the author, who has employed it with advantage in many cases. In the second class may be named sarsaparilla (probably having no other than a purely "stomachic" value); the "McDade formula" (equal parts of the fluid extracts of smilax, sarsaparilla, stillingia sylvatica, kappa minor, and phytolacca decandra, with one-half of one part of the tincture of xanthoxylum carolinianum; and Zittman's decoction (probably efficient chiefly for the mercury it contains). In the last class may be named nitric acid, gold, thuya, cascara, berberis aquifolium, and the mass of proprietary preparations, many of which, though advertised as "purely vegetable" compounds, depend for a short-lived popularity upon the mercury or iodine which they contain. None of the mineral springs, in this country or abroad, which enjoy a reputation in the treatment of syphilis, supplies a water which can be demonstrated to possess a therapeutic value outside of the climatic, hygienic, and, indeed, medicinal effects obtained by residence and treatment by physicians in the districts where such springs are found. The waters of the well-known Hot Springs of Arkansas, in this country, have never yet been shown to possess any medicinal virtue; and the number of syphilitic patients who annually resort thither and reap some advantage from such a course are, for the most part, those who have been treated there with mercury or the iodine compounds by their physicians. Even better results might have been obtained in localities more commended to the intelligent physician on the basis of sanitation. The so-called process of "syphilization" has not survived its brief period of notoriety. It was based upon a confusion respecting the nature of the syphilitic and the non-syphilitic sore, and is now not more than a curiosity in the literature of syphilis.

No limit can be set to the length of time which should be assigned for the treatment of the disease. The average patient requires careful observation and treatment for from two to two and a half years. Many require this for a far longer period. Mild cases may require less. No guarantee of future immunity can be given any patient on the conclusion of treatment, though probably seventy-five per cent. of them all have no symptoms of returning disease after the proper management of their cases by a competent physician. Two years at least should elapse after a mild syphilis before a patient of either sex should be permitted marriage with an uninfected person. In any case, one year of immunity should certainly precede the marriage of an infected man or woman. Two years of immunity is required by some of the larger insurance companies before accepting life-risks of the infected. Syphilis, however, is, as a matter of fact, one of the most readily managed and promising of all diseases that affect the human race. As distinguished from them all, its prognosis may be pronounced good. It may often disfigure, but it rarely destroys, its victims. As against the frequent fatality in pneumonia, variola, typhoid fever, or erysipelas, its statistics include an overwhelming preponderance of infected subjects in whose later years it figures only among those indelible reminiscences which teach the sternest lessons of life.

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The literature of syphilis has accumulated to such an enormous extent that anything like a full bibliography, in the limits assigned to this article, would be impossible. Appended is a brief but selected list of titles, embracing a few of the older classics of syphilitic literature, a number of the modern standard treatises devoted to the subject, and some of the

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James Nevins Hyde.

SZCZAWNICA, though little known in other countries, is one of the most frequented and popular spas in Austrian Poland. It is situated in a pleasant hill-country, lying at an elevation variously estimated at from 1,100 to 1,700 feet above the sea. The climate is mild and agreeable. There are six mineral springs here, with a temperature of from 48° to 52° F., of which the Magdalenenquelle is the richest in mineral ingredients. The following is the analysis of this spring, as given by Kisch in Eulenberg's "Real-Encyclopädie." One litre of water contains:

	Grammes.
Sodium bicarbonate	8.447
Sodium chloride	4.615
Sodium sulphate	0.022
Magnesium bicarbonate	0.786
Calcium bicarbonate	0.874
Ferrous bicarbonate	0.010
Potassium chloride	0.091
Sodium iodide	0.0016
Sodium bromide	0.0085
Organic matters, etc	0.2949
Total	15.1500
	Cub. ctm.
Free carbonic acid	711.5

The waters are given internally and in the form of baths, and milk and whey are also extensively employed.

Szczawnica enjoys a high reputation in the treatment of subacute and chronic catarrhs of the respiratory passages, chronic pneumonia, pleurisy, incipient phthisis, and catarrhal gastritis. It is also frequented to some extent by those suffering from the so-called scrofulous affections of the joints, glands, and skin. The accommodations for visitors are said to be good, and obtainable at a moderate price. *T. L. S.*

TAMARIND (*Tamarindus*, U. S. Ph., Br. Ph.; *Pulpa Tamarindorum Cruda*, Ph. G.; *Tamarinier*, Codex Med.). The preserved pulp of the fruit of *Tamarindus Indica* Linn.; Order, *Leguminosæ Cæsalpinieæ*. The tamarind is a large, handsome, widely spreading, locust-like tree, with rough, dark-gray bark, and rather small, cassia-like, abruptly pinnate leaves of from eight to sixteen pairs of oblong-blunt, oblique leaflets. Flowers, in axillary or terminal racemes of eight or ten each. Calyx irregular,

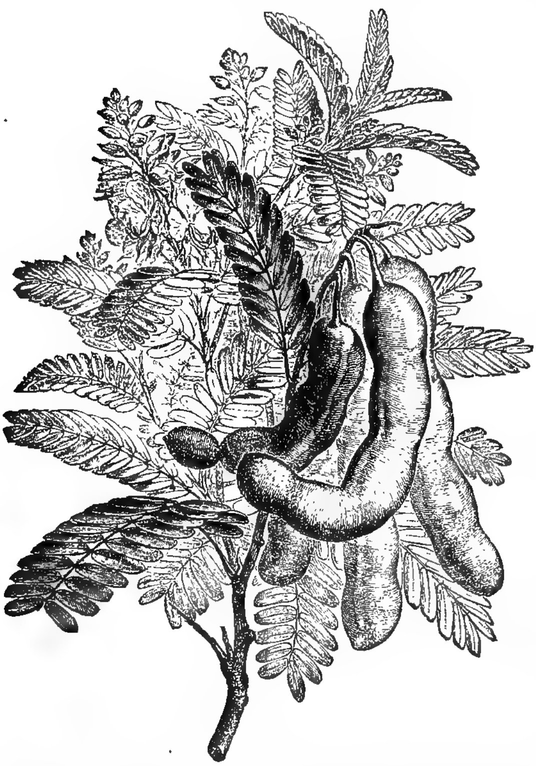

FIG. 3749.—Tamarindus Indica; flowering branch with fruit. (Baillon.)

of four lobes, the upper larger than the others, and colored. Petals three, the upper one smallest, yellow, veined with red. Stamens three, united below. Ovary one, curved upward, one-celled, many ovuled. The fruit is a flattened, curved, solid "pod," from three to six or more inches long; smooth, yellowish-brown externally, with a brittle shell, and a firm acid pulp surrounding the seeds. The pulp contains a skeleton of fibrous bundles running lengthwise over the seeds. The tamarind-tree grows now in all tropical countries, and is, besides, extensively cultivated. It came originally from the Old World, presumably from Africa, but is equally abundant in India, Australia, and the West Indies. The earliest knowledge of tamarinds appears to come from India. They were introduced into Europe during the middle ages.

COLLECTION.—When the fruits are ripe, the outer shell (epicarp) becomes brittle, and is broken between the fingers and removed. The stringy pulp is then packed in kegs and covered with boiling syrup. In this way the West Indian tamarinds, which comprise most of those

that reach our market, are prepared. In the East, sugar is often used instead of syrup, or they may be packed dry, without any sweetening, in a hard, semisolid mass. The seeds are always included.

Preserved tamarinds, as they reach us, are in a moist, reddish-brown, pulpy, stringy mass, with numerous flattish-quadrangular, smooth seeds, and a little thick, dark syrup. They have a pleasantly sourish-sweet taste. Mixed with water they make a pleasant acid drink, which was formerly used in fevers and other forms of sickness. They are very little employed at present.

COMPOSITION.—*Citric acid*, eight or nine per cent., is the most important substance. One and a half per cent. of *tartaric acid*, a little *malic acid*, and, say, three per cent. of *potassium bitartrate*, are adjuvants to the former, and add to the acidity of the fruit. Gum, jelly, and ordinary vegetable matters, and in our preserved tamarinds the sugar that is added, complete the list of ingredients.

USES.—Tamarinds are rather an agreeable luxury than medicine, and in some countries are consumed extensively as a preserve. Here they are used to make a refreshing acid drink, or as an adjuvant to some laxative compound. The Confection of Senna (*Confectio Sennæ*, U. S. Ph.) contains ten per cent. of them. Dose of tamarinds indefinite.

ALLIED PLANTS.—This is the only plant in the Genus. For the Order see SENNA.

ALLIED DRUGS.—Lemons, Barberries, Sumach, Prunes, and other fruits. *W. P. Bolles.*

TANSY (*Tanacetum*, U. S. Ph.; *Tanasie*, Codex Med.). *Tanacetum Vulgare* Linn. (*Chrysanthemum Tanacetum* Karsch), Order, *Compositæ*, is a well-known garden plant and weed, introduced from Europe and thoroughly naturalized. It has a characteristic, rather agreeable and refreshing odor, and a very bitter taste. It contains about one per cent. of a peculiar *essential oil* of a greenish-yellow color, bitter, burning taste, and sp. gr. 0.92, an amorphous hygroscopic, bitter substance, *tanacetin*, soluble in alcohol and water but not in ether, and *malic* (tanacetic) *acid*. Tansy and its oil belong to the more poisonous group of aromatics (camphor, cedar, juniper, turpentine, etc.), producing in large doses vomiting, convulsions, coma, etc., and death. Half an ounce, and even a drachm, of the oil have proved fatal. It is rather frequently taken by women for menstrual irregularities and to produce abortion, which latter, however, it seldom accomplishes. It may be given for same purposes as camphor and turpentine, but has little practical value.

ALLIED PLANTS, ETC.—See CHAMOMILE.

W. P. Bolles.

TAPIOCA (*Tapioka*, Codex Med.). The starch of *Manihot Utilissima* Pohl. (*Jatropha Manihot* Willd.), Order, *Euphorbiaceæ*, the cassava or manioc plant of the West Indies, a native of Brazil, but cultivated as a food-plant in many parts of tropical America. It is a perennial, growing several feet high, with three-, five-, or seven-lobed, palmate leaves, and very large tuberous roots. These latter, which are the edible part, are loaded with starch. When fresh, some varieties, "bitter cassava," contain a bitter, poisonous juice (prussic acid) which is dissipated by washing, expression, drying, cooking, etc. The pulp, ground fine, pressed and dried, and then pulverized, forms cassava meal, which is made into cakes and eaten; the starch washed and dried over a fire, stirred so as to agglutinate into irregular, partly cooked lumps, is the tapioca of commerce. The uncooked starch, like arrowroot in appearance, sometimes called "Brazilian arrowroot," occasionally reaches us.

Tapioca is simply an amylaceous food and has no medicinal properties. For the starches in general and a picture of Tapioca-granules, see STARCH.

W. P. Bolles.

TAR. Tar is a well-known product of destructive distillation of the wood of coniferous trees. It is a peculiarly sticky, semisolid body, nearly black in color, and of a characteristic empyreumatic odor and taste. It is

of acid reaction and very complex composition. By distillation it separates into three portions: one, the acid fluid known as *pyroligneous acid;* One, an empyreumatic oil, called *oil of tar;* and the third, the familiar substance *pitch*. *Pyroligneous acid* contains as its main ingredient *acetic acid;* the *oil of tar* is made up of a considerable number of bodies—*hydrocarbons*—including *benzene, toluene, xylene, naphthalene, pyrene, chrysene, retene,* and *paraffins; phenols,* including *phenol* (carbolic acid), *cresol, guaiacol, creasol, phlorol, methylcresol,* and *pyrocatechin,* besides resins and other substances. *Pitch* consists essentially of the resinous ingredients of the wood. Tar dissolves in alcohol, ether, fixed and volatile oils, and in solutions of potassa or of soda. Water dissolves a small proportion only of the constituents of tar.

Tar partakes of the general medicinal properties of the aromatic hydrocarbons and phenols. It is inhibitory of bacterial growth, is locally mildly irritant and healing, and of a tendency to repress catarrh, and, taken internally, may possibly exert a feeble anti-catarrhal influence through transportation by the blood to the affected spot. Tar has been used locally as an application in skin disease; and, internally, for the relief of catarrhs and urinary affections. It is very much less used now than formerly, its strong odor and taste being objectionable features. Tar is officinal in the United States Pharmacopœia under the title *Pix Liquida*, Tar. For internal administration an official *syrup of tar* is convenient. For the making of this syrup a portion of tar is first washed with cold water, to remove the irritating acid ingredients, and is then treated with boiling distilled water. To the resulting solution, filtered, sugar is then added. This syrup may be administered in teaspoonful doses or more. A *tar ointment* is also an officinal preparation of the United States Pharmacopœia, consisting of equal parts of tar and suet, mutually incorporated into a homogeneous mixture by effecting the mixing with the suet liquefied by gentle heat. This ointment furnishes a convenient means of making local applications of tar to the skin in cases of skin-disease. *Edward Curtis.*

TARASP, called also Tarasp-Schuls and Tarasp-Nairs, is an Alpine health-resort of growing popularity, lying in the Valley of the Inn, in the Lower Engadine, Canton Grisons (Graubündten), Switzerland. It lies at an elevation of about 4,000 feet above the level of the sea, and the climate is consequently cool, though not so cold as might be expected from the elevation, as the place is well protected against the north winds. There are several mineral springs here, of which the best known is the Luciusquelle. The following is the analysis of this water, according to Huseman. Each litre contains:

	Grammes.
Sodium bromide	0.0212
Sodium iodide	0.0008
Sodium chloride	3.6740
Lithium chloride	0.0030
Potassium sulphate	0.3797
Sodium sulphate	2.1004
Sodium borate	0.1722
Sodium nitrate	0.0008
Sodium bicarbonate	4.8788
Magnesium bicarbonate	0.9797
Ammonium bicarbonate	0.0661
Calcium bicarbonate	2.4497
Strontium bicarbonate	0.0007
Manganese bicarbonate	0.0003
Ferrous bicarbonate	0.0215
Phosphoric acid	0.0004
Silicic acid	0.0090
Clay	0.0002
Total	14.7585

There is a large amount of free carbonic-acid gas.

A second spring, the Emeritaquelle, is very similar to this in composition, but is less highly charged with carbonic acid.

The Ursus- and the Badequelle are also similar, but weaker in mineral constituents. These waters, used internally and in baths, are recommended in the treatment of catarrhal troubles of the digestive organs, hepatic disorders, gall-stones, obesity, and all congestive affections of the abdominal organs.

The Bonifacius-, Carola-, and Wyquelle are the chalybeate springs at Tarasp, the former containing about double the proportion of ferrous carbonate that is found in the Luciusquelle. They all contain a large amount of free carbonic-acid gas. These waters are used in the treatment of anæmia, debility, nervous disorders, and other conditions, in which a chalybeate tonic is indicated.

The season extends from the middle of June to the middle of September. The accommodations for guests are said to be good. *T. L. S.*

TARTARIC ACID. Tartaric acid, $H_2C_4H_4O_6$, takes its name from the substance which is its commercial source, namely, the material *tartar* that forms as an incrustation on the inside of wine-casks. Tartar is substantially an impure acid potassic tartrate, which salt by decomposition furnishes free tartaric acid. The acid is officinal in the U. S. Pharmacopœia under the title *Acidum Tartaricum*, Tartaric Acid, and is described as "nearly or entirely colorless, transparent, monoclinic prisms, permanent in the air, odorless, having a purely acid taste and an acid reaction. Soluble in 0.7 part of water, and in 2.5 parts of boiling alcohol at 15° C. (59° F.); in 0.5 part of boiling water and in 0.2 part of boiling alcohol; also soluble in 36 parts of absolute alcohol, in 23 parts of ether, and in 250 parts of absolute ether, and nearly insoluble in chloroform, benzol and benzin. When heated for two hours at 100° C. (212° F.), the crystals do not lose more than a trace in weight. On ignition, they should not leave more than 0.05 per cent. of ash" (U. S. Ph.). Tartaric acid is most often met with in the shops in the form of a white powder, tending more or less to cake into lumps.

Tartaric acid is a pleasantly flavored, sour, so-called organic acid, and in considerable quantity in strong solution is sufficiently irritating to cause dangerous and even fatal irritant poisoning. Several cases of death by tartaric-acid poisoning are on record, and in one of these half an ounce of the acid was the fatal dose. Tartaric acid being cheaper than citric, is often used as a substitute for that acid in the making of artificial lemonade. A six per cent. aqueous solution of tartaric acid may be regarded as the equivalent, in acid strength, of good lemon-juice, and a tablespoonful of such a solution may be used, like lemon-juice, by dilution with sweetened water for the making of an acid draught. A drop or two of essential oil of lemon, triturated with the dry acid before solution, improves the flavor of the draught. Tartaric acid is the acid used in the officinal formulæ of the U. S. Pharmacopœia for the making of effervescent preparations. *Edward Curtis.*

TASTE, THE SENSE OF. The chief organ of the sense of taste is the mucous membrane of the dorsum of the tongue, although, to a less extent, that covering the soft palate, the uvula, and the velum palati is capable of receiving gustatory impressions.

The special nerves presiding over the sense of taste are the glosso-pharyngeus for the posterior third, and a branch of the chorda tympani for the anterior two-thirds of the tongue. The nerves of common and tactile sensation are the glosso-pharyngeal for the posterior, and the lingual branch of the fifth for the anterior two-thirds.

However, this point is far from being definitely settled, some physiologists claiming that the lingual branch of the trigeminus, instead of the chorda tympani, is the gustatory nerve; others, that the only nerve of taste in the tongue is the glosso-pharyngeus, with which the specific nerves of gustation in the anterior two-thirds, after a circuitous route, ultimately unite.

The weight of evidence, both pathological and experimental, seems to be on the side of those who consider the chorda tympani and the glosso-pharyngeus as special nerves.

That the fibres of the chorda tympani terminate in the mucous membrane of the tongue is unquestionably a fact, since, as Vulpian has proved, degenerated nerve-fibres are found in this region after cutting that nerve.

The dorsum of the tongue is covered with stratified epithelium and beset with a number of papillæ of various forms and sizes, richly endowed with vessels and nerves. These papillæ are known as the filiform, fungiform, and circumvallate papillæ.

The filiform papillæ are principally found in the anterior two-thirds of the tongue. They are slender excrescences of the mucous membrane, slightly recurved and beset with epithelia, somewhat after the fashion of inverted ears of wheat. In the feline tribe these epithelia undergo cornification, which enables the animals to use the tongue as a rasp for the separation of the flesh from the bone.

FIG. 3750.—Isolated Cover-cells, from the Taste-buds of the Rabbit. × 600. (From Stricker.)

Probably they are not concerned in taste, but simply serve the purpose of common sensation.

The fungiform papillæ, from one hundred and fifty to two hundred in number, are round, knob-like expansions of mucous membrane, set on short, thick pedicles. They consist of a number of single papillæ and are distributed all over the tongue.

The circumvallate papillæ, numbering about nine or ten in man, are arranged in a V-shaped manner at the base of the tongue. They are elevations of the lingual mucous membrane, bearing on their flattened top numerous stunted papillæ, and are surrounded by a rim, a narrow deep fossa intervening.

Between the epithelia covering the slopes of the circumvallate papillæ and those of the inside of the circular ridge, occasionally also on the fungiform papillæ, peculiarly shaped flask-like bodies are met with, the taste-goblets, or taste-buds, so called from their forms. There are many reasons for looking upon these as being the terminal apparatus of the nerves of taste, notwithstanding that they have also been found on the posterior surface of the epiglottis, which certainly is not concerned in gustation. They are more numerous on the slope of the papilla than on that of the rim, and sit with a broad, rounded extremity on the limiting membrane. They consist of two kinds of cells—the outer, which are fusiform and joined together after the fashion of the leaves of a bud, and the inner, about four or five in number, which are long, slender cells, terminating at both ends in long protoplasmic rods, and containing in their centre a large, shining nucleus. They project slightly through an opening of the investing cells, the gustatory pore.

Although their connection with nerve-filaments has never been clearly made out, it is highly probable that they are analogous to the similarly shaped cells concerned in olfaction, to the rods and cones of the retina, etc.

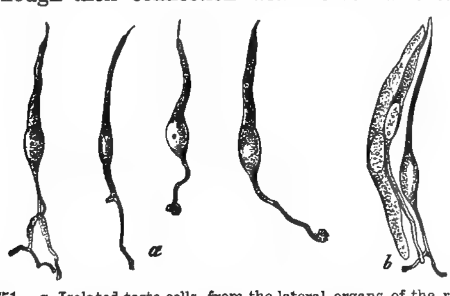

FIG. 3751.—*a*, Isolated taste-cells, from the lateral organs of the rabbit; *b*, a taste-cell and two cover-cells, isolated in a connected condition, from the same source. × 600. (From Stricker.)

At the bottom of the fossa open a number of convoluted tubular glands, secreting a serous fluid during gustation. The object of this secretion seems to be partly to dissolve the sapid substances, partly to wash them away after having been tasted, and thus prepare the terminals for fresh gustatory impressions.

The glosso-pharyngeal nerve-fibres serving common tactile sensation terminate after the fashion of the nerves of the epithelial layers of the cornea and skin; *i.e.*, they end by minute knobs in the cement substance of the epithelia. This manner of nerve termination obtains also in the anterior two-thirds of the tongue, where no special tasting organs are found, and where the nerve-fibres of special sensation terminate, like those of common sensation, between the epithelial cells.

Unlike the olfactory sensations, which cannot be classified, the various kinds of taste are generally divided into salt, sweet, sour, and bitter. These qualities of taste correspond in general to certain chemical groups; thus the salt taste is peculiar to the neutral soluble salts of the alkalies; the sweet, to the poly-atomic alcohols (glycerine, grape-sugar, etc.), which have, as a rule, a sweet taste; the sour to the acids; and the bitter to the alkaloids.

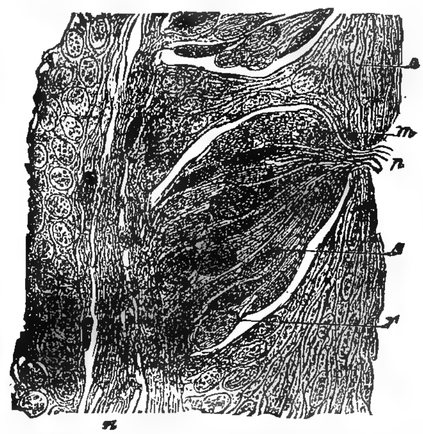

FIG. 3752.—Longitudinal Section of a Taste-bud. *p*, Gustatory pore; *s*, taste-cell; *r*, supporting cell; *m*, migratory cell, containing fat granules; *e*, epithelial cells; *n*, afferent nerve. (From Ranvier.)

There are an infinite variety and an unlimited number of shades of these four fundamental tastes, but the nicer distinctions, in what is generally called the taste of different substances, are made out by olfaction rather than by gustation. Every substance which has a taste has also a flavor.

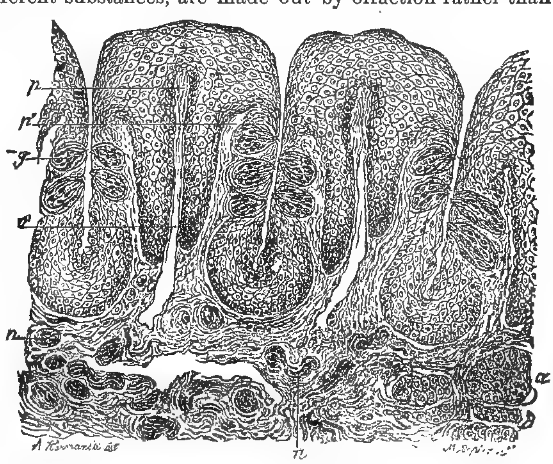

FIG. 3753.—Longitudinal Section of Papillæ Foliatæ of the Rabit. *p*, Central vascular tuft; *v'* transverse section of the central vein of the papilla; *p'*, nervous tuft or papilla; *g*, taste-bud; *n*, *n*, sections of afferent nerves; *a*, serous gland. (From Ranvier.)

The dorsal surface of the tongue does not perceive all the fundamental tastes equally well in all its parts. The sweet is best tasted with the tip, the sour at the edges, the bitter on the posterior third of the tongue. A cat whose glosso-pharyngeal nerves have been cut is said to drink without reluctance milk containg quinine.

Water and alcohol are tasted equally in every part of the dorsal mucous membrane; possibly these fluids give rise only to general sensations, and are not perceived by the special nerves.

The intensity of taste depends on the area to which the sapid substance is applied, on the degree of concentration, and on the temperature. The taste is best perceived of substances registering about 95° F. The interval between the application and the perception of the several sapid substances differs considerably; salt is tasted the most quickly.

In the same manner as colors become more dull when gazed at intently, and as odorous substances (perfumes or flowers, for instance) when smelled too long are no longer perceived, or may even give rise to disagreeable sensations, so the same food, especially when very savory, tasted continually, will exhaust the gustatory apparatus, and become insipid, or even distasteful.

It is not exclusively the sapid substances that give rise to gustatory sensations; a smart tap on the tongue with a small instrument (a lead-pencil or piece of whalebone, for instance) will produce a taste which is not, however, very definite, and is differently classified by different individuals. A fine current of air striking the tongue gives the impression of salt; the continuous electrical current, that of an alkali. The interrupted current does not produce any particular taste. I have found, however, that there are many individual variations in this matter. Thus, some persons distinguish between a bitter, metallic taste at the anode, and an acid one at the cathode.

The senses of touch and of temperature, which are very acute in the tongue, especially at the tip and on the edges, enable that organ to execute the many delicate and complicated movements which form part of its functions.

Hallucinations of taste are, like those of smell, of not unfrequent occurrence in the nervous and insane. The ideas of poisoning in the latter are probably always associated with such hallucinations. They depend on irritation and perverted function of the psychogenic centre, which lies in close proximity to the olfactory centre.

L. Bremer.

TATE EPSOM SPRING. *Location and Post-office,* Tate Spring, Grainger County, Tenn.

Access.—To Morristown by the East Tennessee, Virginia & Georgia Railroad, thence by carriage, ten miles, to the spring.

Analysis.—One pint contains:

	Grains.
Carbonate of lime	2.695
Chloride of sodium	5.033
Chloride of iron	0.365
Chloride of manganese	0.086
Sulphate of potassium	0.192
Sulphate of sodium	1.062
Sulphate of magnesium	3.996
Sulphate of lime	20.082
Phosphate of lime	0.142
Iodide of sodium	traces
Silica	0.337
Nitric acid	0.002
Total	33.992

Therapeutic Properties.—This is a very valuable calcic water, containing sufficient carbonic acid gas to render it very agreeable to the eye and to the taste. It is used with success as an alterative.

The spring is located in Beau Station Valley, at the southern base of Clinch Mountain, in the northeastern portion of Tennessee, at an altitude of 1,400 feet. The fact that it is situated amid the Cumberland and Alleghany Mountains insures grand scenery and pure air. The surrounding country affords fine hunting and fishing. The hotel and cottages are surrounded by a well-shaded lawn. *G. B. F.*

TATTOOING OF THE CORNEA. It has long been known that living animal tissues could be permanently colored by introducing into their substance finely powdered material, non-irritating in its character, that was itself insoluble or was capable of entering into insoluble composition with the tissues themselves.

Apart from purposes of savage decoration and the marking of criminals and prisoners for identification, this knowledge has not been particularly useful to the human race until a very recent date, when De Wecker, of Paris, gave it its recognized place among the expedients of ophthalmic surgery for the covering up of deformities, and occasionally for the improvement of the optical condition of the eye.

It was De Wecker's original intention merely to conceal or to render inconspicuous the unsightly scars, leucomata corneæ, that, when left on the cornea, as the result of injury or ulceration, are especially noticeable on account of their brilliant white appearance in the place where the darker coloring of the pupil and iris is generally seen, and where it often remains in sufficient amount to heighten by contrast the effects of the injury.

Several successful operations of this sort having been done, it was noticed that in some there was an improvement in vision as well as in personal appearance. This improvement, it was supposed, was caused in part by the narrowing of available pupillary area, and in part by the cutting off of that portion of the light which passed into the eye through the bright but irregular scar, thus having in some measure the optical effect of a stenopaic slit.

From these facts De Wecker was led to prophesy for tattooing a more brilliant future than it has since realized, and to think that it might come to be a supplementary operation to those cataract-extractions in which an iridectomy had produced a pupil too large for the best optical effects. The operation is seldom undertaken, however, except for cosmetic effect, and when done for that purpose it occasionally gives very gratifying results.

The substance most frequently used is India ink. That of the best quality should be selected. It is composed of fine lampblack united with a small amount of glue, so that the particles will be held in suspension by the water, which is ordinarily used as a menstruum. Mr. Charles Bell Taylor, of London, in order to obtain the deepest coloring, employed a mixture of India ink, fine lampblack, and nitrate of silver, and used sepia or ultramarine when the color of the iris made it desirable.

De Wecker operated with a lance-shaped knife having a groove on one side to hold the ink, which was made into a thick solution by the addition of water. From five to ten punctures were made at one time by pushing the knife obliquely into the superficial layers of the opaque cornea. These punctures were made as near together as possible, and it was sometimes necessary to repeat the operation five or six times before the desired result could be obtained. Later, multiple punctures were made by the use of seven needles held together in one bundle. There is not so much advantage in the use of the bundle of needles as would at first appear. It takes, of course, seven times the impact to penetrate the tissues with seven needles as with one, and thus more violence is done, while the punctures are more likely to be made in a perpendicular direction than when a single instrument is used. Probably as good an instrument as any for practical use is a fine steel writing pen, the point of which has been sharpened on an Arkansas stone.

To perform the operation the eye should be held open with a speculum and steadied with fixation forceps. Some absorbent, like cotton or sponge, should be held in contact with the lid or the periphery of the globe to drain away the tears as they are formed, so that they shall not wash away the coloring matter as fast as it is applied. It has been found best to work from above downward, so that the overflow of pigment shall not obscure the work as it progresses. The effect of the operation is probably increased by rubbing the pigment over the corneal surface with the end of the finger, so that it shall be well packed into the punctures made by the instrument. When the operation is complete the eye should be allowed to dry for a few minutes before the speculum is removed and the tattooed surface exposed to the action of the tears and lids.

The reaction after this operation is usually very slight,

and the improvement in the appearance is often remarkable; still, it is necessary to remember that many eyes in which the cosmetic effects of tattooing would be desirable are such as will not admit of any unnecessary disturbance, however slight; and where synechiæ exist that have proved themselves to be a source of continued disturbance, or where an irido-cyclitis, a glaucoma, or other destructive process has been going on, this operation is hardly advisable. *W. S. Dennett.*

TAYUYA. The root of *Dermophylla pendulina*, a Brazilian drug introduced a few years ago as a remedy in syphilis, scrofula, etc., has not taken any hold in practice in this country, and is probably without value, at least for the purposes named. It appears to be emetic and cathartic, having properties similar to bryony and other drastic *cucurbitaceæ*. From three to six drops of a ten per cent. tincture is said to be the dose.

W. P. Bolles.

TEETH. DENTAL ANATOMY.—The teeth are commonly divided into two sets, according to the period of their eruption. The teeth which erupt first are variously designated as the deciduous, the temporary, the milk, or the primary teeth. The teeth erupting subsequently to the first set are called the permanent or secondary teeth. In addition to these there are supernumerary teeth, which usually occur in connection with the permanent, but may, in rare instances, be found with the temporary teeth; and there are so-called third dentitions, the genuineness of which, though fairly well established, is not without question.

The permanent teeth are thirty-two in number, sixteen being placed in the upper, and sixteen in the lower, jaw. In each jaw there are four incisors (two central and two lateral), two canines, four bicuspids, and six molars.

A formula to express the number of the various teeth in each jaw is written as follows: I $\frac{4}{4}$, C $\frac{2}{2}$, Bic. $\frac{4}{4}$, molars $\frac{6}{6} = 32$.

The teeth of the upper jaw are symmetrically arranged along the alveolar margin of the superior maxillary bones. When viewed from below, their crowns are found to describe a parabolic curve. This curve, however, varies according to nationality, heredity, and accidental circumstances. The teeth of the lower jaw are arranged along the alveolar margin of the inferior maxillary bone, and their crowns describe a curve similar to that found in the upper jaw. This curve, however, is more pointed in front and more divergent behind. Speaking roughly, the masticating surfaces of the teeth of each jaw lie in a single plane, no crown projecting in a marked way beyond its neighbor. The teeth, also, when normally arranged, show no gap in the row, each tooth thus by its position giving and receiving support. In both these respects human teeth contrast strongly with those of the lower animals. In these it is common to find that certain teeth, as the canines in the carnivora, present a marked elongation, and also that between the teeth there occur intervals which allow of their interlocking.

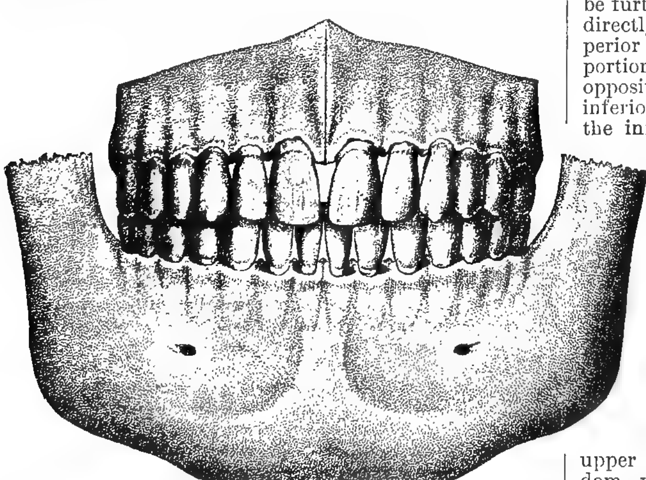

FIG. 3754.—The Permanent Teeth, natural size, showing their method of arrangement and articulation. (Carabelli.)

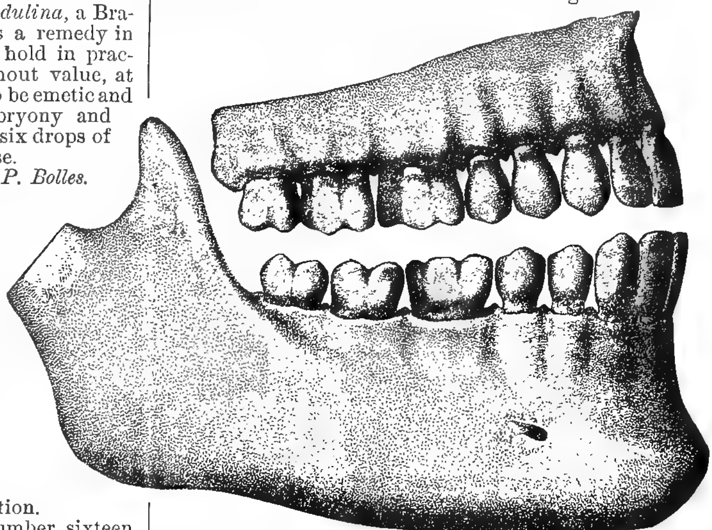

FIG. 3755.—The Permanent Teeth, natural size, showing the curves in the alignment of the crowns. (Carabelli.)

The curve on which the upper teeth of the permanent set are arranged is normally somewhat larger than that of the lower teeth. In consequence, the anterior superior teeth overlap the anterior inferior teeth, as do also to a slight extent the superior bicuspids and first and second molars the corresponding lower teeth. The wisdom teeth, however, meet practically edge to edge. It is to be further noted that the superior teeth are not situated directly opposite corresponding inferior teeth. The superior centrals are opposite the inferior centrals and a portion of the inferior laterals; the superior laterals are opposite a part of the inferior laterals and a part of the inferior canines; the superior canine occludes between the inferior canine and the first inferior bicuspid; the first superior bicuspid occludes between the first and the second inferior bicuspids; the second superior bicuspid occludes between the second inferior bicuspid and the first molar; the first superior molar occludes with the first and the anterior portion of the second inferior molar; the second superior molar occludes with the second and the anterior part of the third inferior molar; the third superior molar occludes with the third inferior molar, and is the only tooth in the upper jaw having a single antagonist. While it has been stated that the masticating surfaces of the teeth of the upper and lower jaws are on a single plane, yet slight deviations from this rule are to be noticed. If we follow the lower edge of the upper teeth from a superior central around to the wisdom, we shall find that the line ascends gently from the central to the interval between the first and second bicuspids, then descends till past the first molar, when it ascends slightly to the end of the row. On the lower jaw the anterior teeth are slightly elevated above the posterior, and between the canine and the wisdom tooth a slight concavity is to be observed.

In its description a tooth is to be divided into a crown, a root or fang, and a neck. The crown of a tooth is that part which normally appears beyond the margin of the

gum. The root or fang is that part which is normally embedded in the alveolus of the maxillary bone. The neck is a more or less constricted belt lying at the margin of the gum where the crown joins the root. The surfaces of the crowns are thus designated. Those surfaces lying adjacent to the lips are called labial surfaces, those lying adjacent to the buccinator muscle are called buccal surfaces. Those surfaces on the inner side of the teeth lying adjacent to the tongue are called lingual surfaces. In the case of the upper bicuspids and molars, however, such surfaces are more commonly called palatal surfaces, from their relation to the hard palate. The grinding surface of the bicuspids and molars is called the coronal surface. The surfaces between adjoining teeth are called approximal surfaces, and are divided into two classes—mesial and distal. The mesial approximal surface of a given tooth is that surface which, were the row of teeth in a straight line, would face toward a line drawn between the central incisors. The distal approximal surface is the corresponding surface at the opposite side of the tooth. These names are, as a rule, applied to the crowns of the teeth, though they are, with the exception of the term coronal, used also in connection with the roots.

Description of Individual Teeth.—The upper central incisor, so called from its chisel-shaped cutting edge, is the most noticeable tooth in the front of the mouth; its crown is wedge-shaped, and is bounded by four surfaces, which are, in a general way, triangular. The anterior triangular surface has for its base the cutting edge of the tooth, its apex lying at the margin of the gum. The anterior surface is convex from side to side, and also from above downward. The posterior surface is opposite the anterior, and, like it, is of triangular shape; the base of the posterior triangle unites with the base of the anterior triangle at the cutting edge of the tooth, while their apices are separated by the antero-posterior thickness of the root. The posterior surface is concave from above downward, and slightly concave or flat from side to side. A prominence can be noticed in the posterior plate near the gum, which is often accompanied by a pit situated at its lower base. Slight ridges run from the lower corners of the tooth posteriorly, and unite with this prominence at the margin of the gum. The cutting edge formed by the union of the anterior and posterior plates has three well-marked tubercles, which, however, are to be seen only in the newly erupted tooth, the friction of mastication soon wearing them away. In connection with the three tubercles on the cutting edge are necessarily two depressions, from which, in many cases, start shallow vertical grooves along the anterior surface of the crown. The lateral surfaces of the crown are triangular, the bases of the triangles being toward the gum and the apices at the cutting edge. The lateral surfaces always show a departure from a perfect triangular form, in having a notch in the base line caused by the encroachment of the cementum of the root upon the enamel of the crown.

The lateral surface toward the median line is convex from above downward; and slightly convex or flat from side to side. Its union with the anterior and posterior plates at the cutting edge forms the lower mesial angle of the crown, which is slightly acute. The distal lateral plate resembles in contour the mesial plate, except that it is more convex from side to side. It helps to form the distal angle of the cutting edge, which is obtuse and decidedly more rounded in contour than the mesial angle. The root of the upper central incisor is, roughly speaking, conical. Three distinct surfaces may, however, be described, one anterior and two lateral, which give to the root a triangular configuration. The anterior surface corresponds in position with the anterior plate of the crown, the two remaining surfaces correspond to the lateral and posterior plates of the crown. The root is much narrower posteriorly than anteriorly, and is thus able to adjust itself to the curve of the dental arch. The pulp cavity of the superior central is simple in form, and follows the external contour of the tooth; it is largest at the neck of the tooth, broad, but very shallow in the crown, and at the apex of the root is reduced to a thread. The neck of this tooth is situated high up anteriorly and posteriorly, but at the sides dips downward, forming a notch in the lateral plates.

The superior lateral incisor is situated at the distal side of the central incisor, and resembles that tooth in its general outlines, though it is much smaller in every dimension. The anterior surface of the crown is narrow and somewhat longer for its width than that of the central incisor; it is convex in both directions. The posterior surface of the crown is concave in its vertical measurement, and flat or slightly concave from side to side. A prominence can be noticed in the posterior plate at the margin of the gum, similar to that described as existing on the central incisor. This prominence is more marked than in the central, and indicates the development of a cusp, which attains its full proportions in the bicuspid teeth.

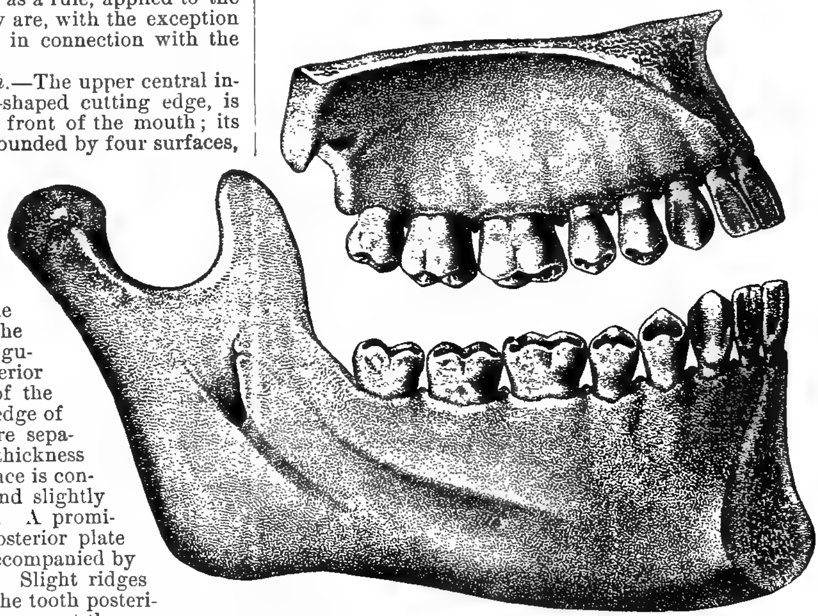

Fig. 3756.—The Permanent Teeth, Natural Size, Internal View. (Carabelli.)

The lateral surfaces of this tooth are convex, the mesial less so than the distal. The crown upon its cutting edge is marked, in the freshly erupted tooth, by three tubercles, as in the central incisor. Between the tubercles are two depressions, with which slight vertical grooves in the crown are connected. The inner angle of the crown at the cutting edge is slightly acute, while the distal angle is obtuse, the corner of the tooth being rounded off to a greater extent than the similar angle of the central. The root of the superior lateral is irregularly conical in shape. It is decidedly more flattened at the side than is the root of the central; it is broadest in front, and is bevelled slightly toward the posterior surface. The pulp-cavity is simple, following the outline of the tooth.

The superior canine is so called because it corresponds to the most prominent and characteristic tooth in the dog. It is also named the cuspid from having a cusp or point at the cutting edge. Popularly it is called the eye-tooth, from its location with reference to the eye. The canine, situated by the side of the lateral, is important in forming the contour of the face, while from its size and strength it is especially fitted for service in mastication.

The crown differs in a marked way from that of the incisors. Instead of its cutting edge being chisel-shaped it is pointed, and thus fitted to pierce rather than cleave. It is easy to trace the development of the crown of the canine from that of the freshly erupted central incisor. As stated above, the newly erupted central has three tubercles on its cutting edge. If the median tubercle is decidedly enlarged, while the lateral tubercles are nearly obliterated, and if, at the same time, the eminence described on the posterior plate of the central incisor be exaggerated, we have substantially the true form of the crown of a canine tooth. The anterior surface of the crown is convex, as are also the lateral surfaces. The posterior surface is concave from above downward, and flat or slightly convex from side to side. The prominence at its upper margin is marked, and is connected with the point of the cutting edge by a slight ridge. This prominence is also connected by similar ridges with the mesial and distal angles of the crown. The distance from the cusp to the mesial angle is less than from the cusp to the distal angle. By this means a right canine can be distinguished from a left. The root of the upper canine is longer than that of any other tooth, and gives rise to a marked ridge in the maxillary bone, associated with a marked depression called the canine fossa. The root, though more or less conical, is flattened laterally and bevelled away from front to back. This bevelling is necessitated by the position which a canine holds, at a decided curve in the dental arch. Slight longitudinal grooves are found at the sides of the root, which indicate a transition to a bifurcated or multiple root. The pulp-cavity is simple in shape and follows the exterior contour.

In passing from the canine to the bicuspid, the shape of the tooth is decidedly changed. According to comparative anatomists there are, in the typical dental formula, four bicuspids on each side of both jaws; and the sharp transition in the human species from the canine to the bicuspid is explained by inferring that the first two bicuspids are absent, and that those present are really the third and fourth, which are therefore somewhat removed in shape from the canine tooth.

The first upper bicuspid, also called the first premolar, has a crown which is rectangular in shape, having a long dimension from within outward and being narrow from front to back. The crown is surmounted by two cusps, hence the name bicuspid; one cusp is external and one is internal. The external cusp is longer and broader than the internal; its outer surface is convex and is continuous with the external plate of the crown. Its coronal surface is convex from side to side, and likewise from above downward. The line from the apex of the cusp to the mesial side of the crown is shorter than the line from the apex to the distal side. The internal cusp is similar in shape to the external, and is connected with it by an anterior ridge which unites the bases of the external and internal cusps along the mesial edge of the crown, and by a posterior ridge which unites the bases along the distal edge of the crown. Between the two cusps is a valley into which the sides of the cusps

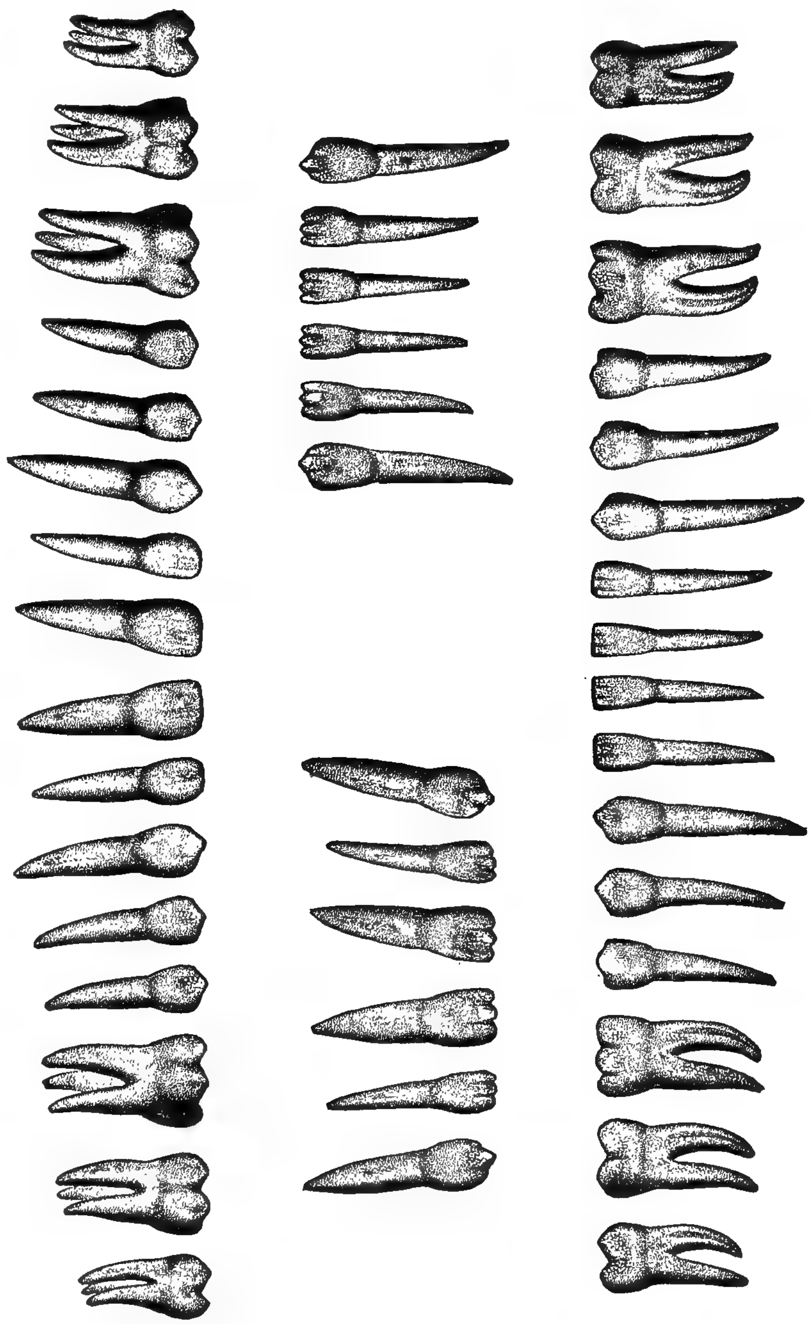

FIG. 3757.—The Permanent Teeth, Natural Size, showing the Labial and Buccal Surfaces. The middle row of teeth represents freshly erupted incisors and canines, with the tubercles on their cutting edges intact. (Carabelli.)

slope. The mesial and distal sides of the crown are convex, especially near the grinding surface, where prominences are developed for contact with adjoining teeth. The neck of this bicuspid is much constricted from its mesial to its distal side. The root is quite long, and is much flattened on its mesial and distal sides, displaying deep vertical grooves; in fact, it is often bifurcated near the extremity. The pulp-chamber is quite narrow from before backward, and is prolonged in the direction of each cusp; in the root it is usually compound, being divided into two compartments by the longitudinal constriction of the root.

The second upper bicuspid, situated behind the first, resembles it in shape. It may be distinguished from it, however, by its root, which is less flattened, thicker from the mesial to the distal surface, and does not tend to bifurcation near the apex. Its pulp-cavity is usually single.

The first upper molar, situated behind the second bicuspid, is the most bulky tooth in the mouth; from its size it plays an important part in giving fulness and ex-

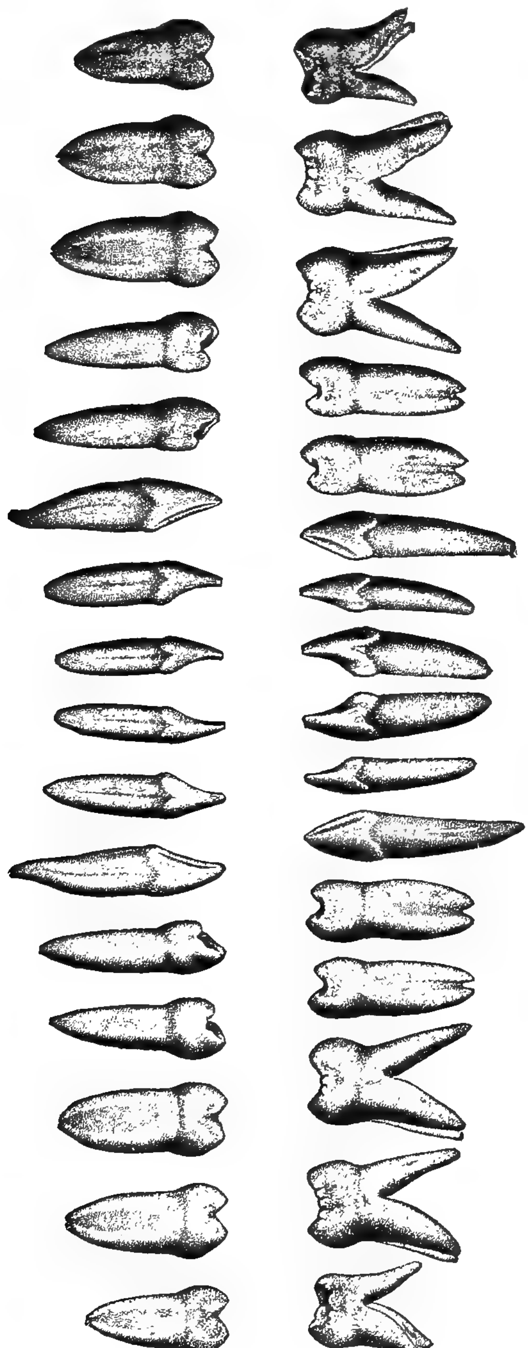

FIG. 3758.—The Permanent Teeth, Natural Size, Side View. (Carabelli.)

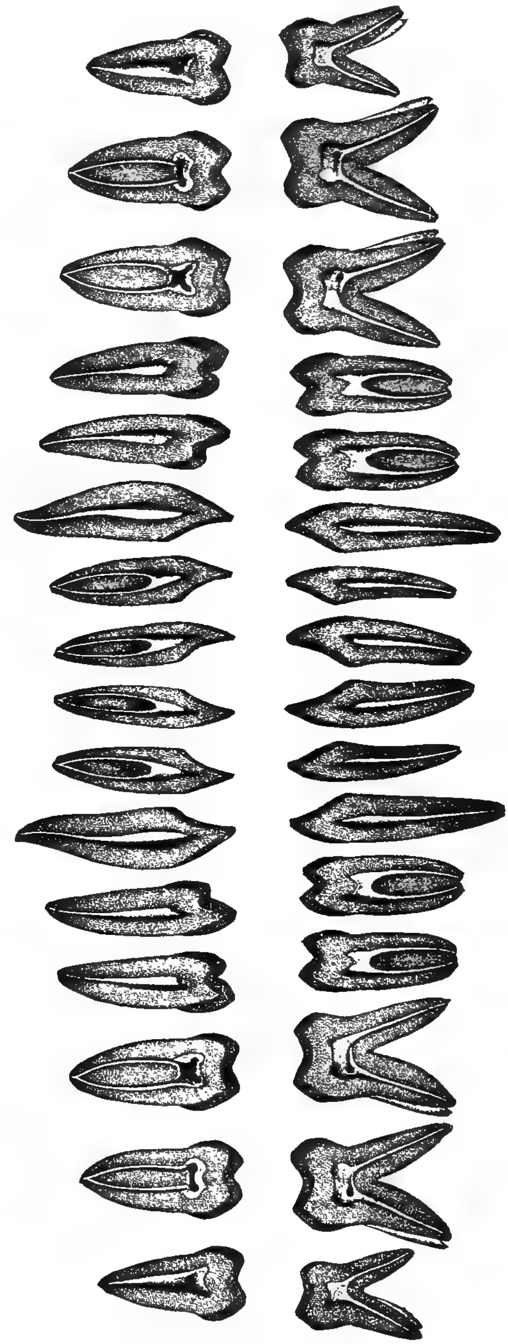

FIG. 3759.—The Permanent Teeth, Natural Size, a Section through the Pulp-cavity, showing its Size and Shape. (Carabelli.)

pression to the side of the face. Its crown is cuboidal in shape, and bears upon its grinding surface four cusps, which are situated at the corners of the cube—two externally and two internally. The external cusps are of about equal size, and are divided by a fissure which starts at the grinding surface and is prolonged vertically up the buccal side of the crown. From the anterior external cusp to the anterior internal cusp there exists a ridge which borders the mesial surface of the crown, and antagonizes with a similar ridge on the distal surface of the second bicuspid. The anterior internal cusp is the largest of the four; it is connected with the anterior external cusp by the ridge just described, and with the posterior external cusp by another, called the oblique ridge. The posterior internal cusp is separated from the anterior internal cusp by the oblique ridge and its valley; and is joined to the posterior external cusp by a ridge which bounds the distal edge of the crown. The roots of the first molar are three in number—two external or buccal, and one internal or palatine. The palatine root is the largest of the three, and underlies the two internal cusps. It diverges from the crown at a slight angle toward the palate; it is conical in shape, but has in many cases a vertical groove on its palatine side, which hints at a division into two roots. The two external roots underlie the anterior and posterior external cusps respectively; they are broader upon the external surface than upon the internal, and diverge lightly outward from the crown, and also from each other. The anterior buccal root is larger in every dimension than the posterior. The pulp-cavity is complex, occupying the three roots and extending into the four cusps of the crown.

The second upper molar, situated behind the first, is similar to it in shape. It is, however, somewhat smaller in all dimensions.

The third upper molar, or wisdom tooth, is situated behind the second molar. In some cases, where a roomy jaw exists, it resembles closely the second molar in shape. As a rule, however, it is imperfectly developed. Its crown is much smaller than that of the second molar, and has three cusps instead of four, two external and one internal. Its root, formed by the confluence of three roots, is through most of its length single, but at the tip usually separates into three. The direction of the root is backward and outward. The pulp-cavity is small, and in the root tends to a threefold division.

The teeth of the lower jaw, though they in general resemble the corresponding teeth of the upper jaw, present many differences. The lower central incisor is much smaller than the upper central incisor; its crown is chisel-shaped, being convex in front, and flat or slightly concave behind. The angles formed by the cutting edge and the body of the crown are both acute, and substantially equal, thus differing from the upper central, whose distal angle is obtuse. The root is long and tapering, flattened on the sides, and slightly bevelled toward the posterior surface. Shallow vertical grooves may be seen upon the anterior face of the crown, similar to those described in the upper centrals. When newly erupted, both lower central incisors possess upon their cutting edges three tubercles and two intervening depressions, but these are soon lost through wear.

The lower lateral incisor is placed on the distal side of the central incisor; it resembles that tooth in shape, but is larger. It will thus be seen that the relative size of the inferior lateral and central incisor is the reverse of that of the superior lateral and central incisor.

The lower canine tooth follows the shape of the upper canine; its crown is, however, not so pointed as that of the upper canine, and its root is more slender. The cusp of the crown is directed somewhat inward, and is thus able to shut inside the teeth of the upper jaw.

The first lower bicuspid resembles in shape the upper bicuspids; its crown is, however, smaller, especially in the labio-lingual dimension. Of its two cusps, the outer is the larger, and is directed slightly inward; the inner cusp is often quite small, and only slightly larger than the rudimentary second cusp of the canine. The root is more conical than are the roots of the upper bicuspids, and, though somewhat flattened on the mesial and distal sides, does not tend toward a bifurcation.

The second lower bicuspid is situated behind the first. Its crown resembles that of the first, but is somewhat larger. The internal cusp is often divided by a slight notch into two cusps, thus indicating a development toward the multicuspid teeth which follow. The root is conical, but flattened on the mesial and distal sides; the pulp-cavity is single.

The lower first molar, situated behind the second bicuspid, is the largest tooth in the lower jaw. Its crown is quadrilateral in shape, and is surmounted by five cusps, three external and two internal. Of the five cusps the external posterior cusp is much the smallest, being oftentimes of rudimentary size. The two internal cusps are larger than the external cusps. A valley at whose bottom is a fissure separates the external from the internal cusps, and a lesser valley separates each cusp from its neighbor. As a rule, a well-defined crucial figure is formed by the fissures in the crown of this tooth. The longer fissure extends from the mesial to the distal side, and the shorter fissure from the buccal to the lingual side, of the tooth. Where the small buccal cusp is present the long fissure bifurcates at the centre of the crown, one branch passing between the second and third buccal cusps, and the main branch directly backward, between the posterior buccal and the posterior lingual cusp. The roots of the first molar, two in number, are situated, one beneath the anterior, and the other beneath the posterior, part of the crown. The two roots, starting from the under side of the crown, diverge from each other at an acute angle, while at the same time they both curve gently backward. The anterior root is much broader than the posterior; it is decidedly flattened from front to back, and has a vertical median groove along its anterior and posterior surfaces. In some cases this root is bifurcated along the line of these grooves, and two distinct roots take the place of the single one which exists normally. The posterior root is conical in shape, though more or less flattened from before backward. It does not tend to subdivision. The pulp-cavity is complex, the anterior root containing two very small root-canals, the posterior root, one single and ample canal.

The second lower molar is situated behind the first, and resembles it in its outlines, though of smaller dimensions. The crown often drops the small posterior buccal cusp and limits itself to four cusps, one on each corner of the crown, and separated by a crucial depression. The roots are smaller than those of the first molar, but have the same configuration and curve.

Fig. 3760.—A Lower Third Molar, with hook-shaped Roots. (Carabelli.)

The third lower molar, where plenty of room exists for its development, resembles the second molar in shape. As a rule, however, it is cramped for room, and becomes dwarfed. Its cusps are diminished to three, two buccal and one lingual. Its two roots are small, and to a large extent confluent. Their backward curve is much more decided than is that of the first two lower molars, and so great is it in many cases that the root resembles a hook, and is thus locked into the alveolus of the jaw.

The *temporary teeth* are twenty in number. In each jaw there are four incisors, two canines, and four molars. The dental formula is I $\frac{4}{4}$, C $\frac{2}{2}$, molars $\frac{4}{4} = 20$.

This formula differs from that of the permanent teeth by the entire absence of bicuspids, and by the loss of four molars. The temporary teeth can best be described by comparing them with the permanent teeth, which they closely resemble.

The incisors and canines of the upper and under jaws are very much smaller than the corresponding teeth in the permanent set, and the root of the upper central incisors is somewhat curved on the mesial side where the corresponding root in the permanent teeth is practically straight.

The first upper molar is situated behind the canine, and in appearance is a compromise between a bicuspid and a

molar. Its crown resembles in general shape that of an upper molar, but is quite small, and bears only three

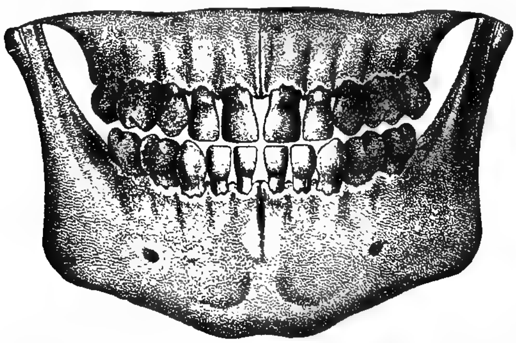

FIG. 3761.—The Temporary Teeth, Natural Size, showing their Arrangement in the Maxillary Bones, and Relations to one Another. (Carabelli.)

cusps—two external and one internal. The roots are three in number, resembling in shape and position those of the permanent molars. They are, however, more divergent, thus providing room for the first bicuspid, whose crown is situated directly beneath the temporary tooth, and within the grasp of its roots.

The second upper molar is a much larger tooth than the first, and resembles so closely the first permanent molar that it might be mistaken for it. Its roots are more divergent, however, in order to embrace the crown of the second bicuspid, to which it gives way in the permanent dentition.

The first molar in the lower jaw is situated behind the canine, and resembles in shape a permanent molar of the lower jaw. Its crown is surmounted by four cusps—two external and two internal. It has two roots, one anterior and one posterior, between which is developed the crown of the first inferior bicuspid.

The second lower molar is larger than the first, and a little smaller than a permanent lower molar, which it closely resembles. Its crown has five cusps—three external and two internal. There are two roots, one anterior and one posterior, which embrace the developing crown of the second lower bicuspid. It is characteristic of the temporary teeth that the foramen at the apex of the roots is larger, that the necks of the teeth are more constricted, and the color whiter and more delicate than in the permanent teeth; also, that the six anterior upper teeth do not overlap the corresponding lower teeth to such an extent as in the permanent set.

FIG. 3763.—An Upper Temporary Molar, with a Bicuspid within the grasp of its Roots. (Wedl.)

MICROSCOPIC ANATOMY OF THE TEETH.—A longitudinal section through a tooth will reveal four distinct structures—the enamel, the cement, the dentine, and the pulp. The pulp is a soft mass of connective tissue richly supplied with blood-vessels and nerves, and located in the centre of the tooth. It fills the pulp-cavity. The pulp-cavity starts at the apex of the root or roots, as the case may be, as a thread-like canal, and gradually enlarges till it reaches the crown, where it attains its greatest size; throughout its whole course it imitates in shape the external contour of the tooth. An artery and nerve, and sometimes more than one of each, enter the apical foramen of each root of a tooth, and, branching freely, distribute themselves to all parts of the pulp, being especially abundant about its periphery. A venous system returns the blood through the apical foramen into the general circulation. It is a matter of dispute whether a lymphatic system is present or not; most observers consider that it is not. Around the periphery of the pulp, and distinct from the connective-tissue cells forming its body, there exists a layer of cells called the odontoblastic layer, or the membrana eboris. In shape these cells are large in comparison with the connective-tissue cells; they are of columnar form, and have several processes. By these processes they are united to the terminal filaments of the nerve of the pulp, joined to one another, and connected with the dentinal fibrils.

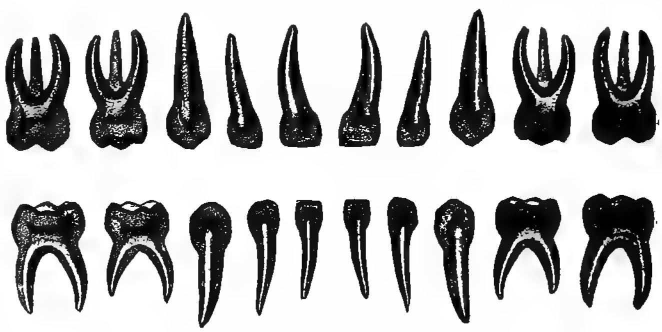

FIG. 3764.—The Temporary Teeth, Natural Size; a Section through the Pulp-cavity shows its Size and Shape. (Carabelli.)

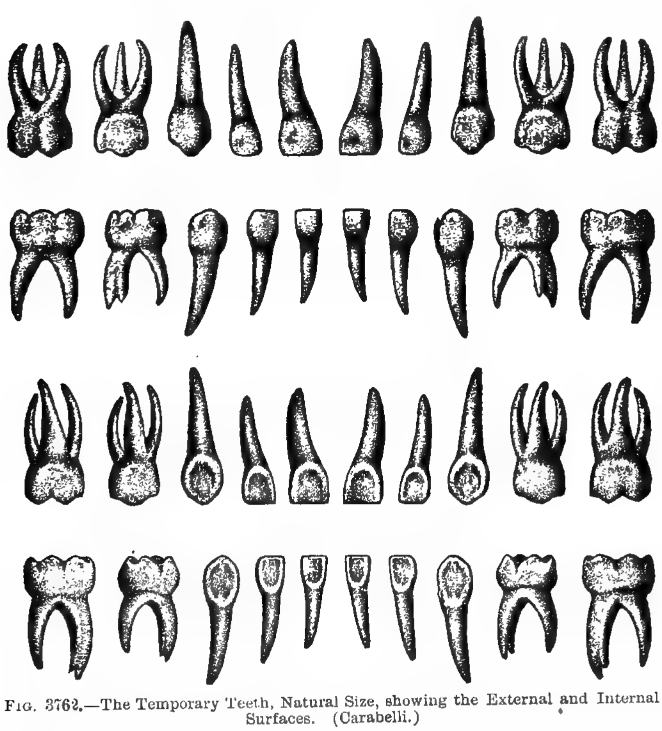

FIG. 3762.—The Temporary Teeth, Natural Size, showing the External and Internal Surfaces. (Carabelli.)

Immediately surrounding the pulp comes the dentine, which is the most abundant tissue of the tooth. It is hard and dense in structure, of a yellowish-white color and silky lustre. On analysis it is found to contain animal matter, twenty-eight per cent.; earthy matter, seventy-two per cent. Its various components are thus given by Von Bibra:

Organic matter	28.01
Phosphate and fluoride of calcium	66.72
Carbonate of calcium	3.36
Phosphate of magnesium	1.18
Other salts	.73
Total	100.00

Morphologically considered, it is composed of a structureless matrix permeated by countless

tubules, each tubule possessing a lining membrane and a central fibril. The tubules start from the pulp-cavity, where they have a diameter of about $\frac{1}{5000}$ of an inch, and radiate toward the periphery of the dentine, becoming smaller and more numerous as they advance. While the direction taken by the tubules in different parts of the tooth varies greatly, yet contiguous tubules are essentially parallel. Two or three undulatory curves are to be noticed in the length of a tubule, and the name primary curvature has been attached to them. Numerous spiral turns occurring in the course of the undulatory curves have been named the secondary curvatures. The tubules give off frequent branches throughout their entire length. Some of these branches are important, extending to the outer layers of the dentine parallel to the main channel. Other branches serve merely to connect one tubule with another, and still others are blind processes. At the outer layer of the dentine the tubules become diminished in size, and very numerous. Some of the tubules can be seen entering the granular layer of the dentine, while others either terminate blindly or anastomose with neighboring tubules. The "granular layer of Purkinje" consists of numerous irregular cavities filled with cells having nuclei, and forming a layer about the peripheral portion of the dentine, being especially well developed where the dentine is covered by the cement of the root. The cavities of this layer communicate with each other, and, in some cases, with the canaliculi of the cement, besides being connected with the tubules of the dentine. The tubules of the dentine have been shown to possess a lining membrane, and to this the name dentinal sheath has been applied. This structure resists the action of reagents which destroy the matrix in which the tubules are embedded, and is supposed to consist of elastic tissue, though its composition is not surely determined. The dentinal fibril which occupies the centre of the tubule is a soft homogeneous substance, having a nerve-like function, but lacking true nerve-structure.

The fibril is connected at one end with an odontoblastic cell in the periphery of the pulp, and the other end enters, in many cases at least, the granular layer of the dentine, coming into contact with the soft tissue there contained. Through the dentinal fibril communication is maintained with the nerves of the pulp, and sensation is supplied to all parts of the dentine. In longitudinal section of that part of the dentine which lies in the crown of the tooth are to be seen lines which are called the "incremental lines of Salter." They run, in general, parallel to the external contour of the crown, and mark stages in the development of the dentine, being not unlike the circular rings of wood-fibre, and are due to the presence of interglobular spaces. That the dentine is developed by stages is made apparent by treating it with hot caustic potash. By this reagent the dentine becomes separated into layers, which cross the tubuli at right angles, and are concentric about the pulp. In the crown of the tooth, between one layer of dentine and another, there occur imperfectly calcified spots where the dentine assumes a globular form, and where irregular interglobular spaces are found. Series of interglobular spaces give rise to the "incremental lines of Salter."

The dentine is surrounded in the crown by the enamel, and in the root by the cementum.

The cementum, or crusta petrosa, is the outer covering of the root. It is thinnest at the neck of the tooth, where it meets and slightly overlaps the enamel, and grows gradually thicker toward the apex, about which point it is most abundant and its structure is most perfectly developed. Cement has essentially bone-structure; it possesses lacunæ and canaliculi, but has normally no Haversian canals. The lacunæ and canaliculi are wanting or rare in that part of the cement near the neck of the tooth, but about the apex of the root they are numerous and well developed. The lacunæ lie in parallel planes encircling the pulp-cavity, their canaliculi anastomose freely with each other, and in some cases they connect with the granular layer of the dentine, thus establishing a communication between the lacunæ of the cement and the pulp of the tooth through the granular layer and tubuli of the dentine.

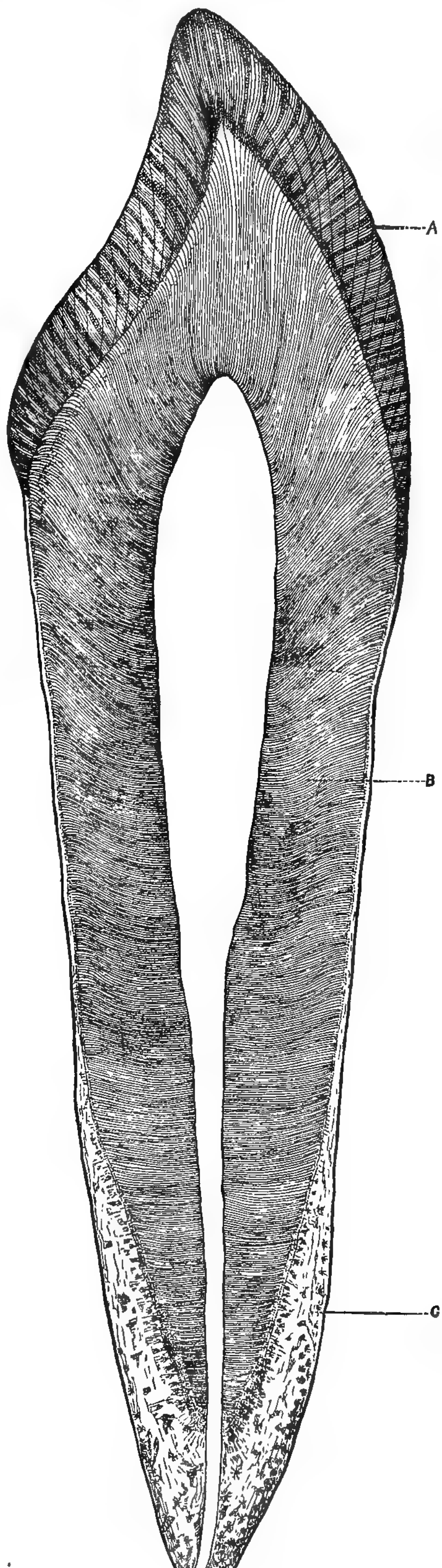

FIG. 3765.—A Microscopic Section of a Canine Tooth, showing, A, the enamel, with its enamel-rods running from the dentine to the outer surface. The dark stripes indicate places where the enamel-rods cross each other. The fine parallel lines are the "brown lines of Retzius." B is the dentine, with its tubules radiating from the pulp-cavity. The undulatory curves of the tubules are called the primary curvatures. The secondary curvatures are not visible at this enlargement. The granular layer is indicated by the dotted line about the periphery. It is especially marked between the cement and dentine, and practically absent between the enamel and dentine. The interglobular spaces are represented in the coronal portion of the dentine just removed from the junction of the dentine and enamel. C indicates the cement, with its lacunæ and canaliculi.

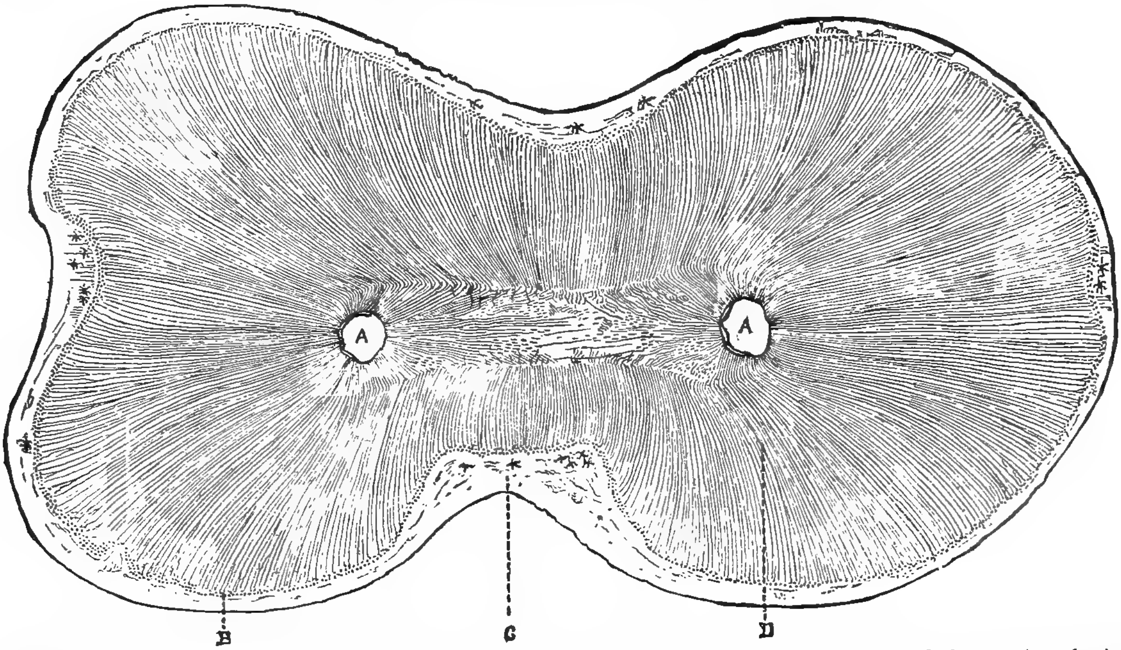

FIG. 3766.—Cross-section of an Upper Bicuspid Tooth. A, A, the root-canals; B, the granular layer of the dentine; C, the cementum, showing occasional lacunæ; D, the dentine.

Immediately surrounding the cementum of the root exists the peridental membrane, which is identical with the periosteum which lines the bone forming the socket of the tooth. The peridental membrane serves a triple function. It nourishes the bone of the socket and the cement of the root, besides forming a bond of union between the root and its socket. The peridental membrane, like all periosteum, is composed of connective tissue richly supplied with blood-vessels. The arterial supply comes from capillaries of the gum about the neck of the tooth, from the deep substance of the bony socket, and from a branch of the artery entering the apical foramen of the tooth.

The enamel forms the outer covering of the crown; it is the hardest structure in the body. It resembles dentine in its chemical constituents, but has a much greater proportion of inorganic material. The following analysis is given by Von Bibra:

Phosphate and fluoride of calcium	89.82
Carbonate of calcium	4.37
Phosphate of magnesium	1.34
Other salts	0.88
Cartilage	3.39
Fat	0.20
Total	100.00

The proportion of organic and inorganic matter is as follows:

Organic	3.5
Inorganic	96.5
Total	100.00

Morphologically considered, enamel is composed of rod-like, hexagonal prisms, arranged side by side, one end of the prism resting on the outer layer of the dentine and the other forming the free surface of the crown of the tooth. Each prism extends, as a rule, through the entire thickness of the enamel. There are some, however, which extend only from the centre of the enamel to its free surface, thus preventing gaps which would otherwise occur, the outer surface of the enamel being of greater extent than the inner. In diameter the enamel prisms measure $\frac{1}{5000}$ to $\frac{1}{7000}$ of an inch. Each prism, when isolated, has slight varicosities and presents a striped appearance similar to muscular fibre. The prisms run, in general, parallel to each other, and in a wavy course; their inner ends are implanted in slight hexagonal depressions in the surface of the dentine, and their outer ends are received into similar depressions in the under side of the cuticle of the enamel when the cuticle is present. A vertical section of the enamel shows that it is thickest in the crown, especially in the region of the cusps, and becomes thinnest at the neck of the tooth, where it is overlapped by the cement of the root. The enamel-prisms are seen to leave the outer surface of the dentine at right angles, and radiate toward the external surface of the tooth. The general yellowish-white color of the enamel is varied by dark bands extending vertically from the dentine to the free surface of the enamel, caused by the crossing of bundles of enamel-prisms. Certain delicate lines running longitudinally through the substance of the enamel are also to be noticed. These are called the "brown lines of Retzius," but

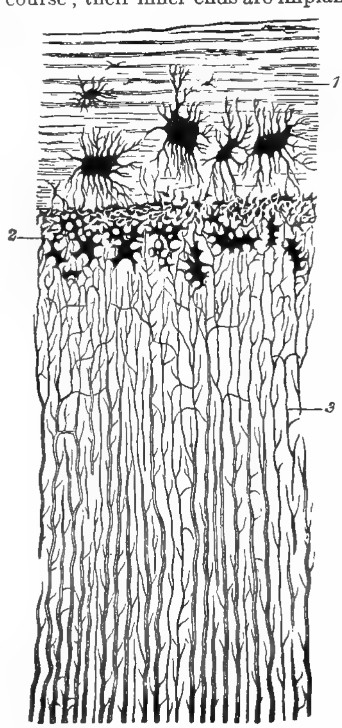

FIG. 3767.—A Section of Dentine and Cement. The figure 1 represents the cement with its lacunæ and canaliculi; the figure 2 represents the granular layer of the dentine. It is to be noticed that the lacunæ communicate with the cells of the granular layer. The figure 3 represents the tubuli of the dentine, showing their diminution in size as they go toward the cement, also their frequent anastomoses and their connection, in some cases, with the cells of the granular layer. (Quain.)

it is not known to what they are due. Also between enamel rods, usually near the surface of the dentine, are found irregular cavities due to an imperfect calcification of the enamel. On cross-section the enamel has the appearance of a mosaic pavement, each prism showing its hexagonal shape. The small amount of organic material which exists in enamel is deposited mainly between the prisms, forming a cement which binds them together. This cement is more abundant in young than in adult teeth.

The cuticle of the enamel, or Nasmyth's membrane, is to be found in a freshly erupted tooth. It consists of a delicate epithelial covering which encloses the enamel; it

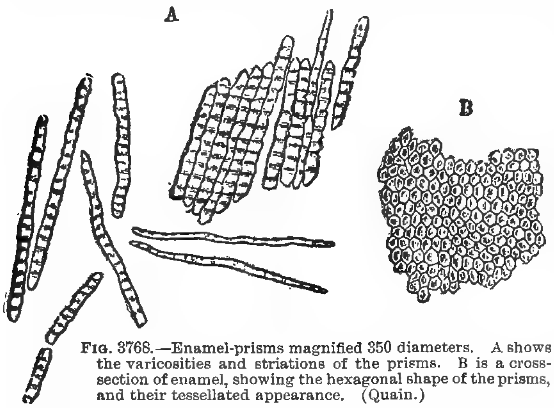

FIG. 3768.—Enamel-prisms magnified 350 diameters. A shows the varicosities and striations of the prisms. B is a cross-section of enamel, showing the hexagonal shape of the prisms, and their tessellated appearance. (Quain.)

is, however, so delicate that in the slightest use it is worn away. It receives in hexagonal depressions on its under side the outer ends of the enamel prisms.

TIME OF ERUPTION OF THE TEETH.—The first dentition begins about the seventh month, and is completed about the twenty-fourth month. The second dentition begins about the sixth year, and is completed about the twenty-first. Considerable variation exists in the time at which individual teeth erupt, and no date can be absolutely fixed for the appearance of a given tooth. It is possible, however, to state the time when the eruption of a tooth is normally to be expected, and the following tables are appended:

Temporary Teeth.

The central incisor erupts at the	7th month.
The lateral incisor erupts at the	9th month.
The first molar erupts at the	12th month.
The canine erupts at the	18th month.
The second molar erupts at the	24th month.

Permanent Teeth.

The first molar erupts at the	6th year.
The central incisor erupts at the	7th year.
The lateral incisor erupts at the	8th year.
The first bicuspid erupts at the	9th year.
The second bicuspid erupts at the	10th year.
The canine erupts at the	11th year.
The second molar erupts at the	12th year.
The third molar erupts at the	17th–21st year.

As a rule, in both the first and second dentitions the lower teeth erupt before corresponding teeth in the upper jaw.

PHYSIOLOGY OF THE TEETH.—Under this head we naturally consider the purposes for which teeth exist, and how they perform their several functions. The subject may be divided into three heads:

(1) The function of the teeth in facial expression. (2) The function of the teeth in mastication. (3) The function of the teeth in articulation.

The importance of the teeth in facial expression becomes apparent when we consider the effect of their absence, as shown in aged people. In such the lower part of the face has lost the round and graceful lines of early years; the chin is pointed, and approximates the end of the nose; the lips are retracted and flabby, and a characteristic hollow extends along the cheek. When present, each tooth aids in sustaining the proper proportions of the face. The upper front teeth, by being slightly in advance of the lower, produce that slight projection of the upper lip beyond the lower, found in normally shaped features. The bicuspids and molars, by their apposition, fix the relation of the lower to the upper jaw, and by their bulk give fulness to the cheeks. The bony alveolus, also, in which the teeth are embedded, has an important relation to facial expression, for when a tooth has been lost, its bony support, being no longer needed, is absorbed, and thus the features are still further deprived of support.

The function of the teeth in mastication is the most obvious and important. Standing as they do at the entrance to the digestive tract, it is their duty to seize upon food, sever its connection with its surroundings, and comminute it so that it can be acted upon readily by the various digestive fluids. The act of seizing and cutting is performed by the six anterior teeth, whose edges, by the protrusion of the lower jaw, are brought opposite to each other. When once a morsel of food has been detached by the anterior teeth, it is passed backward by the tongue and cheeks, to be operated upon by the bicuspids and molars. The bicuspids are fitted both to cut and to grind. They cut by the outer cusps of opposing teeth meeting and passing each other like the blades of a pair of scissors. They crush by a lateral motion, the crowns of the lower bicuspids moving across those of the upper. The function of the molar teeth is to crush and grind, for which purpose they are fitted by their broad crowns. They crush by means of an up-and-down movement, and grind by a lateral movement.

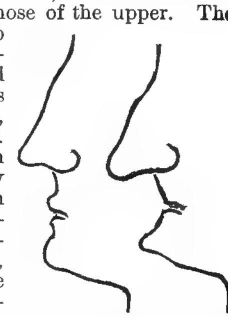

FIG. 3769.—The first profile represents the features undisturbed by loss of teeth. The second represents the edentulous condition, in which the lips fall in and the chin becomes pointed and inclined toward the nose.

The function of the teeth in articulation is best understood by a brief survey of the mechanism of speech. This mechanism includes the vocal cords, and a resonant cavity above the cords, formed by the pharynx and the oral and nasal cavities. This resonant cavity reinforces and modifies sounds made by the vocal cords. Articulation is concerned with sounds of two kinds—vowels and consonants. The vowels are musical notes formed by the vocal cords, and given quality or timbre by the size and shape of the air-column in the resonant cavities above. The consonants are sounds produced by the same mechanism, but due to irregular vibrations, and hence are noises. The oral cavity, being able to change its size and shape in numberless ways, is the most important agent in sound modification.

To produce articulate sounds the column of air must be obstructed and forced into channels of definite size and shape. The column of air is obstructed in three ways: first, by applying the back of the tongue to the palate; second, by applying the tip of the tongue to the posterior surfaces of the anterior teeth; and third, by a closure of the lips. It is forced into definite channels by pressing the tongue against different parts of the roof of the mouth, and against the inner surface of the upper teeth.

To produce the sound T, the tip of the tongue is placed against the posterior surface of the upper incisors, while the sides of the tongue touch the bicuspids and molars on both sides. With the tongue in this position a column of air is held under pressure and suddenly released through the front part of the mouth with an explosive sound. D is made in a similar way. F and V are made by bringing the lower lip against the under side of the upper incisors, the tongue meanwhile touching the inner surfaces of the upper second and third molars. A column of air is then forced out between the upper incisors and the lower lip. The letter S is sounded by nearly shutting the teeth and forcing the air between them, the tongue meanwhile being placed against the upper bicuspids and molars, and thereby narrowing the oral cavity to a slight channel along the roof of the mouth.

To pronounce Sh, the teeth are closed and the tongue is placed against the upper bicuspids and molars, leaving a narrow channel along the roof of the mouth. Along this channel a blast of air is forced which escapes between the front teeth with a hissing noise.

The agency of the teeth in the formation of the consonants is recognized by grammarians in their separation of the consonants into labials, palatals, and dentals. Although the teeth are important for perfect articulation, yet when lost they are to a great degree compensated for by an increased activity of the lips, cheek, and tongue. These parts so adapt themselves to the diminutive alveolar ridge which remains that fair articulation is still possible. What most seriously interferes with articulation is the loss of one or two of the front teeth while the others remain. In such a case the adjoining structures exercise their compensatory function with difficulty, and sounds depending for their formation upon the presence of the front teeth are not easily made. The loss of the back teeth is compensated for by the drawing in of the cheek and the bulging outward of the tongue. By this means it is possible to carry a column of air to the front of the mouth and prevent its escaping at the sides.

As a minor function of the teeth may be mentioned their tactile sense, by which, together with the muscular sense located in the muscles of mastication, the degree of hardness of bodies is perceived. This tactile sense of a tooth is dependent on the sensitive peridental membrane, which perceives and records the impact of the tooth against every substance.

Pathology of the Teeth.—*Pathology in the Number of Dentitions and their Time.*—While two is the normal number of dentitions, much can be heard and read of a third dentition, the authority for which, however, rests, as a rule, with unscientific observers, and is of very little value. It is a fact of common observation with dentists that individuals know very little accurately of what is going on in their own mouth, and consequently often make positive but inaccurate statements with regard to their teeth. The statements of parents, also, with regard to the condition of their children's teeth, are very unreliable; they fail to distinguish temporary from permanent teeth, supernumerary from normal teeth, and a normal from an abnormal number. The teeth are sometimes so irregular that a double row exists at some parts of the arch, and the phenomenon is explained as due to a third set of teeth. The late eruption of certain teeth, notably the wisdom, which may be delayed till middle or advanced life, often gives rise to a reported case of third dentition, a few teeth being represented as a whole set. The matter is so clearly stated by Salter that I cannot do better than quote from the "Dental Pathology" (Wm. Wood & Co., 1875, p. 32), as follows: "There is no recorded instance of the occurrence of a third set of teeth in the writings of any modern observer of scientific repute; but the authorities of earlier date who have asserted the fact are so respectable that it is difficult altogether to discard from one's mind the idea that the circumstance has occurred in some shape." Later authorities than Salter, while in the main holding his view, yet strengthen somewhat the probability of the occurrence of a third dentition by cases which have been under fairly good observation. The conclusion to be drawn is, that a third dentition probably has occurred in rare instances, but that the vast majority of reported cases are spurious, the error having been caused by the presence of supernumerary teeth, irregular and crowded teeth, or by teeth which have been delayed in their eruption till late in life.

While the existence of an extra dentition remains in doubt, the entire absence of one or both of the normal dentitions is an established fact; such cases, however, are decidedly rare, especially those in which neither dentition has occurred. There is usually associated with this condition a failure in the growth of hair throughout the body. The condition of the alveolar ridge in such cases is similar to that which ensues on the extraction of the permanent teeth. Artificial substitutes, however, are not always necessary, inasmuch as the gum, in such cases, is very tough, and capable of performing with remarkable facility the duties of mastication.

Pathology in the Time of Dentition.—The deciduous teeth are sometimes erupted at birth. An interesting statement of cases of this kind is given in the "American System of Dentistry," vol. iii., p. 423: "Pliny the Younger has handed down to us several instances of prenatal dentition, the most conspicuous of which was that of a Roman consul, Marcus Curius, who, on account of being born with a full set of teeth was surnamed Dentatus. Zoroaster, the Persian legislator, is also said to have had a complete set of teeth at birth. Louis XIV. of France, and his Secretary of State, Cardinal Mazarin, were each born with two teeth. Richard III. of England, and Mirabeau, are both said to have had congenital teeth. Haller collected a list of nineteen cases of teeth at birth, and very many more have been recorded by others." When deciduous teeth are delayed in their eruption it is commonly due to rickets. A delay in the eruption of the permanent teeth is also frequently noticed. An important cause for this delay is the prolonged retention of the deciduous teeth, an obstacle being thus present which prevents the permanent teeth from taking their place. Cases are on record of deciduous teeth persisting till middle or old age. It often happens, however, that a permanent tooth is kept from eruption because its place has been taken by another permanent tooth which had an earlier start, and which has occupied all the available room. This is especially liable to happen with the superior canines, on account of their coming to the surface after the lateral and the first bicuspid have taken their place in the arch. If, as often happens, the temporary canine has been prematurely extracted, allowing the adjoining teeth to close in the gap, or if the arch is unusually narrow, or the teeth unusually large—and sometimes the two latter conditions exist together—then the canine is likely to be crowded out beyond the arch or to be imprisoned in the alveolus. The canine may be permanently imprisoned, or until the extraction of a bicuspid or lateral incisor offers it a chance to erupt.

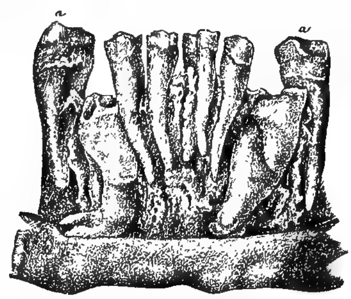

Fig. 3770.—Illustrates the Impaction of both Lower Canines. It occurred in a person of advanced age, and the impacted teeth were not visible above the gum. The canines are kept from eruption by the neighboring bicuspids and lateral incisors. (Wedl.)

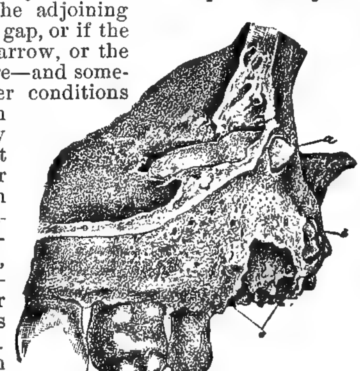

Fig. 3771.—Illustrates the Impaction of a Right Superior Lateral (*a*), which lies in the superior maxillary bone at right angles to its normal position. (Wedl.)

The wisdom teeth are always very liable to detention within the jaw, and their eruption may be either prevented or long delayed. This happens from causes similar to those just described with regard to the canine. The modern civilized jaw seems to be made too short to contain a full complement of developed teeth, and, as the wisdom teeth come last, they, though of stunted size, are frequently unable to enter the arch. Imprisoned or partly erupted wisdom teeth, especially of the lower jaw, may cause very serious symptoms, both local and reflex. The local symptoms consist of pain and swelling in the vicinity of the tooth; the reflex symptoms of neuralgias about the

head, and a tonic contraction of the muscles which close the jaw. In some cases an abscess may be formed which, if lacking prompt exit, may open by fistula on the outside of the face at the angle of the jaw, or in the neck, or even as low down as the subclavicular region. Imprisoned canine and incisor teeth are sometimes found far from their normal position. Cases are cited where the crown of the superior canine has penetrated the nasal cavity and the antrum. Canines have also been located in the palatine portion of the superior maxillary bone. Lower canines have been found with their long axes parallel to the body of the jaw, at or near the tips of the roots of the inferior lateral and bicuspids. The superior lateral may be delayed in its eruption, or imprisoned for want of room in the arch, and may in consequence take abnormal positions similar to those taken by the superior canine.

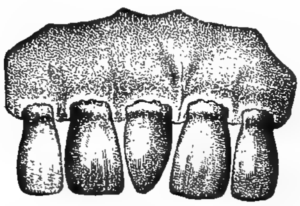

Fig. 3772.—A Conical Supernumerary Tooth located between the Superior Central Incisors. (Carabelli.)

Pathology in the Number of Teeth in a given Dentition. —In connection with both the first and second dentitions we find, at times, both an excess and also a deficiency of teeth. Teeth in excess of the normal are called supernumerary teeth. Such may be coincident in time of eruption with the teeth in whose neighborhood they appear, or they may precede or follow. Supernumerary teeth are divided into two main classes —teeth whose form differs from that of normal teeth (conical teeth), and teeth whose form resembles that of normal teeth. Supernumerary teeth are not common in connection with the first dentition; when they occur they are found more frequently in the lower jaw, and belong in shape to the second class, inasmuch as they resemble the teeth with which they are associated. The duplicate tooth is usually a lower incisor, and it takes its place regularly in the arch, being erupted at about the same time as its companion incisor. Supernumerary teeth are more frequently found in connection with the second dentition, and are usually located in the upper jaw.

They as a rule make their appearance just after the adjoining tooth is erupted. Conical supernumerary teeth are the most common kind. They have the same structure as normal teeth, but in shape resemble a diminutive cuspid. Their crown, however, has not the angular outline belonging to that tooth, but is cone-shaped, as their name implies. The root is round and tapering. These teeth occur most frequently in connection with the superior incisors. One may be located between the two centrals in the arch, or between the central and the lateral. They may be placed without the arch, on either its labial or palatal side. Conical teeth are not commonly found adjoining the molars, bicuspids, or cuspids, though they may exceptionally be found in all these localities. If found outside the arch, conical teeth are of no value, and should be extracted; if found in the arch, it often becomes a question whether their presence or absence produces the greater deformity. Supernumerary teeth which resemble normal teeth are generally found among the upper incisors and regularly placed in the arch; they do not necessarily produce deformity, and by the unprofessional eye would not be noticed. A supernumerary superior lateral is most commonly found; next in frequency comes the superior central, while duplicates of the superior molars, bicuspids, and canines are rare. Carl Wedl, in his "Pathology of the Teeth," gives a drawing of the superior and inferior maxillæ of a negro, in which appear four molars on each side of both the upper and under jaw, beside an extra bicuspid in the lower jaw, making five supernumerary teeth in all; the molars are all in the dental arch, but the bicuspid is situated at the inner side of its neighboring bicuspid. A third kind of supernumerary tooth, sometimes described, is called the cubic-crowned tooth; it resembles in shape the lower bicuspid, and occurs in the anterior part of the mouth behind the superior incisors.

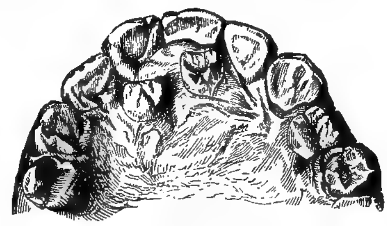

Fig. 3773.—Shows two Cubic-crowned Supernumerary Teeth, occurring behind the Upper Central Incisors. (Salter.)

Pathology in the Arrangement of the Teeth.—A pathological arrangement or irregularity may affect groups of teeth or individual teeth. Among the irregularities which affect groups of teeth are cases in which the anterior teeth of the upper jaw project so far in advance of the corresponding teeth of the under jaw that a considerable space exists between the anterior surface of the lower teeth and the posterior surface of the upper teeth. This arrangement is in many cases hereditary, but may be induced by thumb-sucking in infancy. Infants addicted to this habit place the thumb between the front teeth and pry the upper teeth forward, using the under as a fulcrum. The force exerted is very slight, but, being continued for perhaps several hours during the day, is sufficient to move the imperfectly calcified bony alveolus.

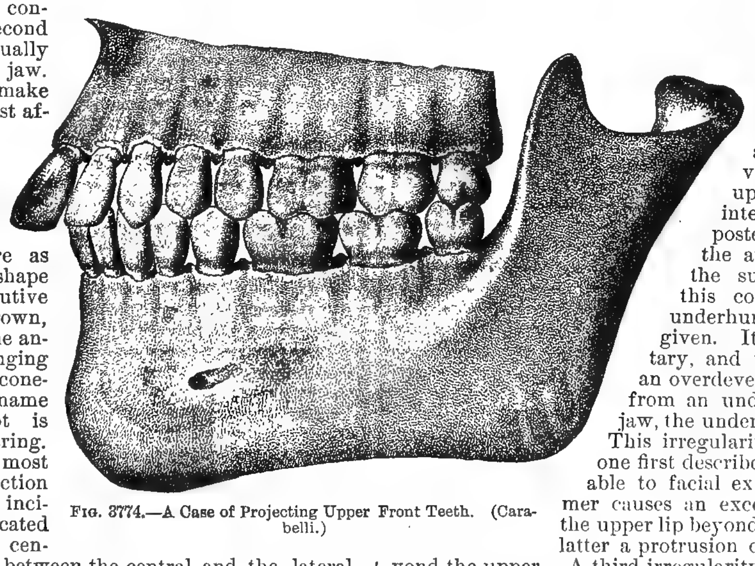

Fig. 3774.—A Case of Projecting Upper Front Teeth. (Carabelli.)

An irregularity the reverse of the above, and of frequent occurrence, is produced when the anterior teeth of the under jaw are placed in advance of those of the upper jaw, leaving an interval between their posterior surfaces and the anterior surfaces of the superior teeth. To this condition the name underhung jaw has been given. It is usually hereditary, and results either from an overdeveloped under jaw or from an underdeveloped upper jaw, the under jaw being normal. This irregularity, as well as the one first described, is very unfavorable to facial expression. The former causes an excessive protrusion of the upper lip beyond the under, and the latter a protrusion of the under lip beyond the upper. A third irregularity is produced when the superior anterior teeth, instead of slightly overlapping the inferior anterior teeth, meet them edge to edge. This arrangement causes no marked facial blemish, but is detrimental to the teeth, which become worn away by edge to edge contact, and thereby shortened.

The six anterior teeth of both jaws are sometimes tilted forward to a marked degree. This irregularity is commonly caused by the loss of molar and bicuspid teeth, which allows the whole force of occlusion to come upon

the anterior teeth. This irregularity causes the upper and under lips to protrude.

On the other hand, the six anterior teeth of both jaws may be inverted, and a corresponding falling in of the lips occur.

A V-shaped jaw is often seen; this irregularity is confined to the upper jaw, whose alveolar arch, instead of being in the form of a parabola, becomes so contracted in front that it resembles in shape the letter V. In such a jaw the room for the tongue is much diminished, and a thick and somewhat indistinct articulation may result.

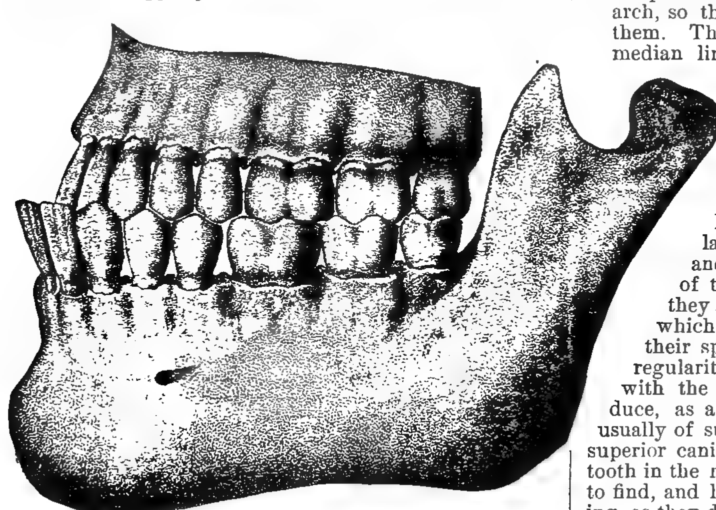

FIG. 3775.—An Underhung Jaw, the Lower Front Teeth in advance of the corresponding Upper Ones. (Carabelli.)

There are cases in which the back teeth are of undue length and prop the mouth open so wide that the anterior teeth do not meet. Such an arrangement is likely to keep the lips from closing, except as the result of conscious effort.

The dental arch may be asymmetrical. Such a condition may be congenital, or produced by tongue-sucking in infancy. In this habit the tongue is crowded against the alveolus bordering the upper molars and bicuspids, a constant repetition of force in this direction unevenly spreading and thus distorting the dental arch.

The "flat mouth," so called, is produced when the six anterior teeth of both jaws are arranged in nearly a straight line instead of in a curve. When so placed they join the bicuspids at a right angle, or nearly so, and give a characteristic flatness to the expression about the mouth.

These various irregularities are, as a rule, confined to the permanent set. An underhung jaw has, however, been noticed in the temporary set, followed by the same in the permanent.

Irregularities of individual teeth are to be explained by several causes, of which the most important is the occurrence of a small-sized jaw associated with large-sized teeth, a small-sized jaw being inherited from one parent and large teeth from the other.

The premature extraction of the temporary teeth is responsible for many cases of irregularity. The place of each temporary tooth is taken normally by a tooth of the permanent set, and, unless the temporary tooth remains *in situ* till the permanent is ready to be erupted, there is danger that the place which the permanent tooth should occupy will be encroached upon by an adjoining tooth.

The too long retention of the temporary teeth may produce irregularity. In this case the temporary teeth become an obstacle to the descending permanent teeth, and may deflect them from their course, forcing them to appear inside or outside the dental arch; or, as not infrequently happens, keeping them imprisoned within the maxillary bones.

Irregularities of individual teeth of the temporary set are rare. There may be a slight twisting or lapping of the incisors, but no great deformity has been observed. Most important irregularities occur in the permanent set; the superior central incisors may stand inside the dental arch, so that the inferior centrals close in front of them. Their crowns may be rotated either toward the median line or away from it, or may overlap each other. In the lower jaw the central incisors, owing to the frequent crowding of the lower anterior teeth, are often twisted or overlapped. The superior laterals are more frequently irregular than are the centrals. The most common irregularity consists in the crown of the lateral overlapping that of the central. The laterals may be placed within the dental arch and held in that position by the interlocking of the lower teeth. Sometimes it happens that they are prevented from eruption by the canines, which have, by premature eruption, occupied their space. The inferior laterals are liable to irregularities similar to those described in connection with the inferior centrals; such irregularities produce, as a rule, no marked deformity, and are not usually of sufficient importance to be regulated. The superior canines are more often irregular than any other tooth in the mouth. The reason for this is not difficult to find, and has already been partly explained. Erupting, as they do, subsequent to the lateral and first bicuspid, it often happens that the space necessary for their regular appearance in the dental arch has been encroached upon by the adjoining teeth. In consequence the canines must either take a position on the outside of the arch or within. Sometimes the canine takes a position alongside the central incisor; when this is the case, the displaced lateral is usually within the arch. A rotated canine is not uncommon; the rotation being toward the median line or away from it. The lower canines are seldom irregular. The upper first bicuspid also usually finds its normal place, on account of the period of its eruption and the fact that its crown is smaller than that of the first temporary molar which it supplants.

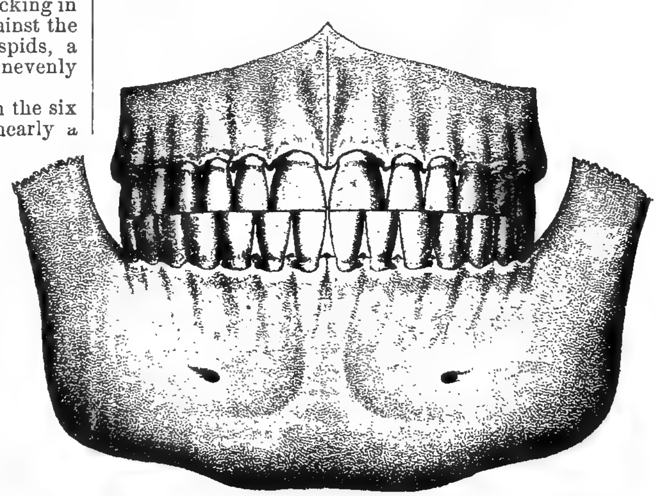

FIG. 3776.—A Case in which the Front Teeth meet Edge to Edge. (Carabelli.)

The second upper bicuspid is much more frequently out of place than is the first. Though its crown takes up much less room than that of the second deciduous molar, which it replaces, still the teeth adjoining it, namely, the first bicuspid and first molar, being in position some time before the second bicuspid is ready to erupt, may encroach upon the space which should have been reserved for that tooth. Such a condition

usually results from the too early extraction of the second deciduous molar. As a result of such extraction the neighboring teeth move together, and sufficient

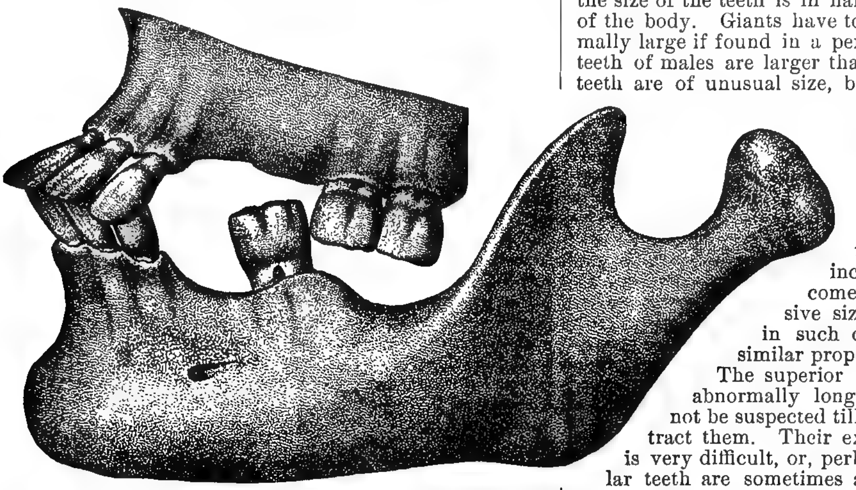

FIG. 3777.—Protrusion of the Anterior Teeth, caused by loss of Bicuspids and Molars. (Carabelli.)

room is not left for the free eruption of the second bicuspid, and that tooth, in consequence, finding its way in the direction of least resistance, is compelled to appear within or without the dental arch, as the case may be. The lower bicuspids are subject to irregularities similar

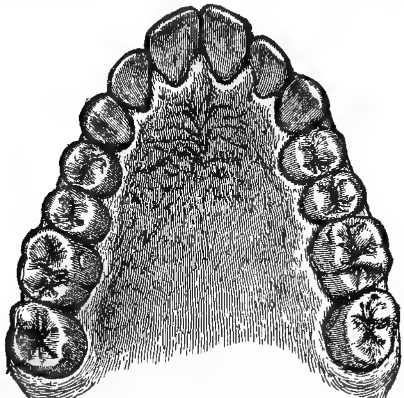

FIG. 3778.—A V-shaped Upper Jaw, from Kingsley's "Oral Deformities." (By permission.)

to those of the upper bicuspids, although they occur less frequently. The first and second molars are rarely irregular in either jaw; each in turn being developed behind teeth already in place, there is nothing to crowd them from their normal position. The third molar, on the contrary, has scanty room for eruption, and in consequence presents frequent irregularity. The lower third molar is often found with its crown presenting toward the posterior surface of the crown of the second molar. Sometimes it is tipped forward so far that the force of occlusion and mastication is borne upon its distal surface. This is the most usual form of irregularity, but the tooth may assume almost any position, even with the crown pointing backward toward the ramus of the jaw. The most frequent

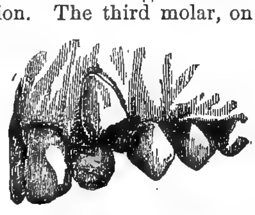

FIG. 3779.—Is a case in which the superior canine has not room to erupt regularly in the arch, and is forced to appear outside of the arch. (Salter.)

irregularity of the upper wisdom tooth is the turning of its crown outward or backward.

Pathology in Size and Shape of the Teeth.—As a rule, the size of the teeth is in harmony with the proportions of the body. Giants have teeth which would be abnormally large if found in a person of ordinary size. The teeth of males are larger than those of females. When teeth are of unusual size, but proportioned to the size of the individual, they are normal for that individual. There occur cases, however, in which certain teeth are entirely out of proportion to the alveolar arch. Such teeth may be too large or too small. Upper central incisors, in rare instances, become a monstrosity in the excessive size of their crowns; the roots in such cases are not developed in similar proportion.

The superior canines sometimes possess abnormally long roots, whose length may not be suspected till an attempt is made to extract them. Their extraction, on this account, is very difficult, or, perhaps, impossible. The molar teeth are sometimes abnormally developed, the crowns and roots alike being of unusual size. An abnormal diminution in the size of the teeth is not commonly found, except in the case of the upper wisdom

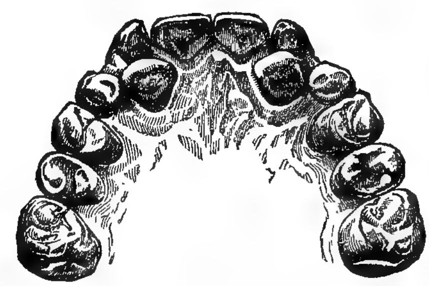

FIG. 3780.—A case in which the superior canines have not room to erupt regularly in the arch, and are forced to appear within the arch. (Salter.)

teeth, which are often quite small, no larger than a conical supernumerary tooth. Teeth which are pathological in shape are frequently observed. Their unusual shape may be due to a constitutional disturbance, occurring during their formative period, or it may be due to a freak of nature—a cause unknown. Of the irregular shapes produced by a constitutional disturbance is to be noticed a pitting of the enamel of the six anterior teeth, and sometimes of the molars in either jaw. The pits may penetrate the entire surface of the enamel, or only a part of it. They may be irregularly disposed, or, as usually occurs, may be arranged in horizontal rows, of which there may be two or three in a single crown. Sometimes the pits are stained a yellowish or yellowish-brown color. This irregular development is caused by some severe infantile disease occurring during the period in which the enamel

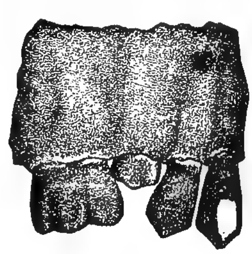

FIG. 3781.—The Right Upper Canine, First and Second Bicuspids, and First Molar. The first molar and first bicuspid have moved together, probably on account of the premature extraction of the second temporary molar. The second bicuspid is thus prevented from erupting regularly, and must force its way outside the arch. In some cases further eruption would cease, and the tooth would remain in the position represented. (Carabelli.)

FIG. 3782.—Represents a superior canine with an unusually long root. (Carabelli.)

of these teeth is being calcified, the process of calcification being thus interrupted. The administration of mercury in the early years of childhood has also been con-

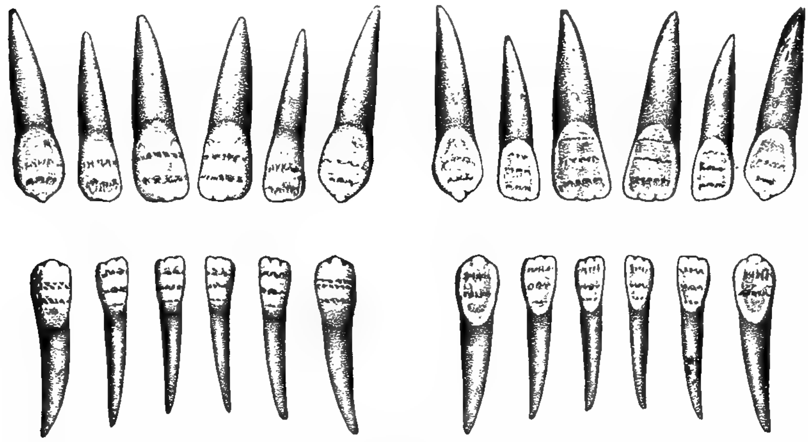

Fig. 3783.—A Pitting of the Enamel of the Six Anterior Teeth, due to infantile disease arresting the process of calcification of the enamel. (Carabelli.)

sidered by some to account for this irregularly formed enamel, but such a view is not now generally accepted.

Another malformation due to a constitutional disturbance is that produced by inherited syphilis. The effects of this disease upon the teeth are most notably seen in the upper central incisors of the permanent set. The crowns of these teeth are stunted in size, are somewhat irregularly placed, and their cutting edges are narrower in width than are the necks of the teeth. The enamel on their cutting edges is imperfectly developed and soon crumbles away, leaving crescentic notches. The upper laterals and canines, as well as the lower centrals, laterals, and canines may be affected in a similar but less marked way. The first molars are usually imperfectly developed, and from a loss of enamel the corners of the teeth are rounded off, giving to the crowns a domelike appearance. As the characteristics of teeth affected by inherited syphilis were first described by Jonathan Hutchinson, it is common to call such teeth Hutchinsonian teeth. They are also called notched teeth, from the notch which may be found in the cutting edge of the six anterior teeth. This notch, however, is obliterated by wear, and thus in time becomes lost as a diagnostic sign. The term peg teeth in this connection is commonly used, and refers to the peglike appearance of the crowns of the anterior teeth. The peg shape does not become obliterated by wear, and always remains a diagnostic sign.

Fig. 3784.—Represents a case of pitting of the enamel, due to arrested calcification. (Carabelli.)

Fig. 3785.

Fig. 3786.

Figs. 3785 and 3786 illustrate the effects of hereditary syphilis on the superior incisors of a boy and a girl, aged twelve and fourteen years, respectively. These cases came under the observation of Henry W. Williams, M.D., and are copied by permission, from his "Diagnosis and Treatment of the Diseases of the Eye."

While inherited syphilis does not always leave its mark upon the teeth, yet when the appearances described are present they are considered to be positive evidence of this disease. The temporary teeth are said, by good authority, to be sometimes affected by hereditary syphilis, and to become notched and peg-shaped after the manner of the permanent teeth.

Pathological shapes to be ascribed to a freak of nature are not commonly met with; still, a large number of such cases have been reported, and drawings made to illustrate them. As one of the more frequent irregularities may be mentioned the fusion of adjacent teeth. There are two kinds of fusion; in one the union is accomplished by the cement of one root becoming increased and uniting itself to the cement of another root. In such cases each tooth has a separate pulp-cavity and independent nourishment, the union being merely upon the outside and not affecting the individuality of either tooth. The other kind of fusion consists in the union of the dentine as well as the cement, and a fusion of the pulp-cavities into a single irregularly shaped space. Such teeth have a common and interdependent life.

Fig. 3787.—A Case of Fusion of the Superior Central and Lateral Incisors.

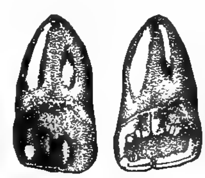

Fig. 3788.—Complete Fusion of the Superior Central and Lateral Incisors. Anterior and posterior view.

Fusion of this kind may be confined to the roots or include the crown as well, in which case a union occurs between the enamel of the two teeth. Fused teeth may be found in the temporary or in the permanent set, and any teeth may be so affected. Generally the fusion is confined to two teeth. It is sometimes unsuspected when involving only the roots, and the attempt to extract either of the fused teeth may result in its companion also being dislodged, or in a failure to extract either. The first form of fusion probably takes place after the formation of the teeth, the latter while the teeth are in a developmental stage.

There are irregular shapes not due to fusion, and which come under the head of miscellaneous forms. The incisors sometimes have their crown developed at right or obtuse angles with their roots, or have more than one root. The canines may have a twisted root, or one with a sharp bend occurring at the middle or upper end of its length. The bicuspids may have two or even three roots. In consequence of the tendency of the roots of the bicuspids to bifurcate, this occasional development of two distinct roots is to be expected. The upper and lower molars may have as many as five roots, or all their roots may be fused into one.

Fig. 3789.—A Right Superior Central Incisor whose root is developed at right angles to the crown.

Pathology of the Component Tissues of the Teeth.—Of these tissues the pulp is most subject to pathological changes. Normally this delicate and sensitive organ is well guarded by rigid walls, which not only protect it against external force, but also against the extreme thermal changes to which the oral cavity is exposed. So long, then, as the pulp remains thus protected, it is not subject to pathological changes; morbid processes do not originate in its tissue. It is true that there are writers who describe affections of the pulp independent of outside influences, but the genuineness of such cases has not been well established. In general the pulp is subject to pathological

Fig. 3790.—A Left Superior Central Incisor having a supplementary root.

changes similar to those found in the soft tissue in other parts of the body; such peculiarities as are found are due to the existence of the pulp within a bony encasement. It must be borne in mind that the pulp is very vascular and very sentient; that the vessels and nerves are supported by a parenchyma of connective tissues, and that the whole organ is contained in an unyielding cavity whose only entrance and exit is a small foramen, whose calibre may not be larger than a bristle. Through this foramen the blood enters, and is in due time returned—a delicate piece of machinery capable of easily performing its duties when in natural adjustment, but impaired or destroyed when affected by force from without. Any agency which interferes with the protection which nature has thrown around the pulp is calculated to set up morbid changes in its structure and interfere with its function. The most potent and frequent agency to be named is caries. When once this disease has located itself upon a tooth it usually progresses, unless checked by appropriate mechanical means, till a considerable portion of the enamel and dentine are destroyed and the pulp laid bare. Long, however, before the pulp is reached, it has been subjected to conditions unfavorable to its healthy activity, and the chances are that when exposed by caries it is already in a pathological condition.

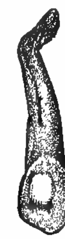

FIG. 3791.—A Right Superior Canine with an abrupt Curve at the end of the Root.

An agency in producing disturbances of the pulp, less important than caries, is the natural wearing away of the substance of the teeth in the process of mastication. Such wear is usually without serious effect upon the pulp up to the period of middle life. Subsequent to that time, however, it may so deprive the pulp of its natural covering as to induce pathological changes.

FIG. 3792.—A Superior Bicuspid with Two very long Roots.

A third outside agency, and one less frequently met with than the other two, is mechanical violence, in the form of a blow or fall, of such a nature as to sever the union between the pulp and its blood- and nerve-supply. Under such circumstances the pulp, as a rule, dies. There are, however, cases reported in which a sound tooth having been pushed out of its socket has been replaced, and the pulp has apparently remained in a healthy condition. Such cases lend support to a supposition that a reunion is possible between the pulp and its blood- and nerve-supply; but this point has not yet been satisfactorily settled.

One of the simplest and commonest pathological affections of the pulp is congestion. A pulp examined in this condition shows increased redness, due to an increased flow of blood to the part and dilatation of the vessels. This condition is brought about through the vaso-motor system, which responds to an irritation of the dentinal fibrils, which are in connection with the nerves of the pulp, and so with the general nervous system. Inasmuch as the normal pulp fills its cavity, an increased supply of blood must compress the tissue in the neighborhood of the vessels. The nerves share this compression, and hence the severe pain which is the usual accompaniment of a congested pulp. Caries of the tooth is the most common cause of congestion of the pulp. Through it a cavity in the direction of the pulp is produced which allows hot and cold drinks, food, and cold air to approach so near the pulp that they irritate it. Salt and sweet substances, also, if allowed to enter the cavity produced by the caries will act upon the dentinal fibrils and irritate the pulp. A congested pulp is hypersensitive, giving pain upon the slightest occasion. A draught of cold water, the effect of which upon a normal pulp might be but a momentary twinge, would cause a congested pulp to ache violently. This ache is one of the more common kinds of toothache; it is violent, intermittent, throbbing. It is very likely to be worse at night when the body is in a recumbent position. Congestion of the pulp does not necessarily result in a permanent pathological condition, provided the environment of the pulp can be so improved as to become normal, or nearly so. The normal environment may be restored by filling the cavity produced by caries, the pulp being thus removed from the near approach of heat or cold and irritating substances. The filling material should be a poor conductor of heat and cold, resembling in this respect, as far as possible, enamel and dentine. Gutta-percha or oxyphosphate cement have proved the best substances with which to protect a congested pulp. It frequently happens that the pulp becomes congested in a tooth which contains a large metallic filling. The metal filling, being a good conductor of heat and cold, conveys injurious shocks deep into the dentine and unfavorably affects the pulp. Such a condition may be remedied by substituting a non-metallic filling for a metallic one.

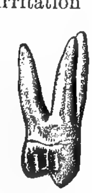

FIG. 3793.—A Superior Bicuspid with Three Roots.

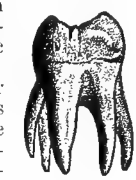

FIG. 3794.—A Molar Tooth with Five Roots.

While a congested pulp may recover its normal condition, it frequently passes into a state of inflammation which may be either acute or chronic. In acute inflammation there succeeds to the active hyperæmia of congestion a stasis of blood in the inflamed portion; the vessels become dilated more than before, and often assume a tortuous course. The leucocytes can be seen leaving the capillaries and invading the surrounding tissue. If the inflammation is purulent, pus cells and broken-down tissues become abundant. The affection may be local, confined to a small point which has been exposed by caries, or it may be general, involving the entire pulp. The organ is swollen, as in congestion, and pain results from pressure upon the nerve-fibres. If the inflammation is very violent, it is likely to destroy the life of the pulp in a short time, through pressure upon the blood-vessels at the foramen. The symptoms attending an inflammation of the pulp are similar to those of a congested pulp, but more severe. The pain is violent, throbbing, paroxysmal, and is commonly known as a "jumping toothache." The tooth is extremely sensitive to heat and cold, to sweet and salt substances, and to pressure within the cavity of decay.

Such an acute inflammation may subside or pass into a chronic inflammation, the symptoms of which resemble those of the acute, but are of a less severe grade. The cause of inflammation of the pulp is caries, which, as a rule, has penetrated to the pulp cavity and laid bare a minute portion of that organ, exposing it to the irritation of foreign bodies, thermal changes, and the secretions of the oral cavity. When suppurative inflammation occurs, the probable agency of bacteria is of interest, as it is well known that many varieties of these organisms exist in the mouth. Their approach to the pulp is made easy through the carious cavity, which lays bare the pulp, and the conditions seem favorable for their peculiar activity. Dr. H. C. Ernst says, in his "Consideration of the Bacteria of Surgical Diseases" (p. 4): "The point being determined that there is at least a very strong probability that no suppuration occurs without the presence of bacteria, the study of the organism concerned in these processes becomes at once of great interest." Dr. Black, in the "American System of Dentistry," while admitting the probability that micro-organisms are influential in suppurative inflammations of the pulp, says that in the cases which he has examined he has as yet failed to discover their presence. The course pursued by an inflammatory affection of the pulp depends largely on the extent to which its surface has been exposed through caries. That there is always such an exposure in case of inflammation of the pulp cannot be affirmed, but that it does exist in the large majority of cases is attested by experience. If this exposure is small and allows no relief to the swollen

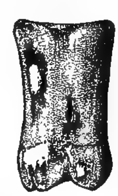

FIG. 3795.—A Molar Tooth whose Roots are fused into one.

condition of the organ, and no sufficient outlet to products of inflammation, then an acute inflammation is likely rapidly to destroy the pulp, and transmit an inflammatory process along the root canals to the peridental membrane. If, however, the pulp has been freely exposed before an inflammation has been started up, then the inflamed pulp has a way of relief to its enlarged substance, and an exit for the products of inflammation. Such cases are more likely to assume a chronic form, inasmuch as the life of the pulp is not immediately threatened. It is a matter of some chance, in the case of a pulp exposed by caries, just how soon an inflammatory affection will be started up, though no pulp when once exposed can long escape. If the cavity which exposes the pulp is hidden away in the back of the mouth, or protected by adjoining teeth, so that the pulp of the tooth is, in a measure, protected from alternations of temperature and severe contact with food, then the inflammatory affection may be delayed, and, when it does come, decay may have so opened the pulp cavity as to greatly modify the severity of the inflammation. On the other hand, when caries attacks the crown of the first molar and lays bare the pulp, it is immediately subject to severe irritation in the process of mastication, and trouble begins at once. Inflammatory affections of the pulp do not tend to recovery, but generally end in death of the pulp. This result may be, however, somewhat delayed by appropriate treatment. The exposed pulp may be capped over with non-irritating, non-conducting material, and thus shielded. It is sometimes possible to prolong the life of the pulp several years, provided the treatment is not long delayed after the beginning of the inflammatory affection. After having been thus treated the pulp may give no further sensation of pain; it does not, however, often regain its normal condition when it has once passed through the inflammatory process.

To alleviate the pain of a congested or inflamed pulp it is important, first, to determine which tooth is giving trouble. The testimony of patients cannot be relied upon to settle this point. They can usually indicate correctly the side upon which the affected tooth is located, but will often point to a perfectly sound tooth as the cause of their pain. A thorough examination should be made, by the aid of the mouth-mirror and a fine exploring point, of all suspected teeth. If a tooth is found with a carious cavity of any considerable size, especially if the cavity is sensitive to the touch of an instrument, it is fair to infer that such a tooth is the one giving pain. The diagnosis can be confirmed by the application of a little cold water to the cavity of decay. Where a congested or inflamed pulp exists, this application will cause an exacerbation of the pain.

Having located the tooth which is the seat of the difficulty, its carious cavity should be washed out with a syringeful of warm water, in order to remove irritating particles of food. The next step is to make an application to the exposed pulp, or, if the pulp is not exposed, to the dentine in the neighborhood of the pulp, which will allay the pain.

A simple and efficacious remedy is the oil of cloves. More powerful remedies are: Carbolic acid, ninety-five per cent.; creasote; a mixture of equal parts of oil of cloves and chloroform; a mixture of equal parts of oil of cloves and creasote.

One drop of any of these remedies is usually sufficient for a single application. The medicine should be applied to the cavity on a pledget of cotton. Care should be taken not to press the cotton too tightly into the cavity, as it might thus become a mechanical irritant to an exposed pulp. In the use of concentrated carbolic acid, care should be taken to prevent its spreading to the adjoining gum and mucous membrane of the lips and cheek.

It is very important, in treating toothache, to know whether the pulp in the affected tooth is alive or dead. If alive, it will respond to thermal changes and be sensitive to exploration in the carious cavity, and should be treated as just described. If the pulp is dead the tooth is usually sore to percussion, and unaffected by applications of cold, though heat will usually be painful.

It is not sensitive to the exploration of an instrument in the cavity of decay. The carious cavity of such a tooth should not be plugged with any dressing, but should be opened freely to give vent to the decomposing pulp in the manner described in the section on affections of the peridental membrane.

Closely allied to inflammation of the pulp is abscess of the pulp. This affection, clinically, cannot always be distinguished from the preceding. Upon microscopic examination, however, it is possible to make out true abscess cavities. These may be deeply situated in the body of the pulp, or near its surface.

The microscopical examination of a diseased pulp is conducted in the following manner: An aching tooth, which is presumably in a pathological condition, is extracted and at once dropped into Müller's fluid; here it is to remain for several weeks till the pulp has become somewhat hard. Then the tooth, after having been wrapped in a cloth, is to be put between the jaws of a vise, and carefully cracked open, and the pulp removed from its cavity. The pulp is again subjected to Müller's fluid, and then to gum arabic, which permeates its sub-

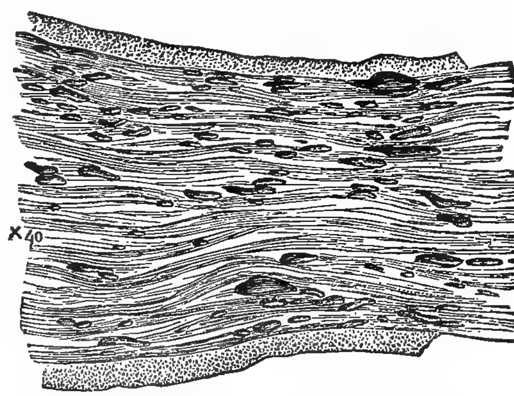

FIG. 3796.—Initial Points of Calcification occurring in the Pulp.

stance and forms a stiff coating outside. The whole mass is then mounted in paraffine, and is in condition to be cut with a microtome. In this way the relation between clinical symptoms of the pulp and pathological changes in that organ can be accurately traced.

Among the more advanced pathological changes in the pulp may be mentioned gangrene. This, as in other parts of the body, may be moist or dry. Gangrene follows upon the sudden cutting off of the circulation from the pulp, as a result of acute inflammations, or violence to the tooth of such a kind as to sever the artery at the apical foramen. A gangrenous pulp is of a grayish-green color, of slight consistency, and fetid odor. In such a pulp the normal structural elements become undistinguishable. In dry gangrene the pulp contracts to a very small compass, and the part of the pulp cavity thus left vacant is occupied by a gas of decomposition. Gangrenous pulps, unless the pulp cavity is freely opened, produce severe inflammation of the peridental membrane.

Another group of pathological changes embraces the various forms of calcification to which the pulp is subject. Among such may be mentioned the nodular form. In this variety small nodules of calcareous matter are sprinkled through the substance of the pulp, giving to it a gritty feel. The calcareous matter is similar in chemical composition to dentine, but does not have its characteristic structure. The calcareous nodules are located between the component parts of the pulp, and are not formed at their expense. This condition seems to be compatible with a healthy activity of the pulp, and apparently does not lead to serious consequences. Its etiology has not been explained. Another form of calcification exists, in which the new-formation takes the place of the normal tissue of the pulp and is formed at its expense. The calcareous points are found scattered here

and there through the pulp, usually in the coronal portion. These points become confluent till an aggregation is formed ranging in size from a grain of sand up to a mass sufficient to fill the entire pulp cavity, coronal and radical portion as well. This form of calcification apparently does not take place when the tooth is in a normal condition, but seems to be induced either by the wearing down of the crowns of the teeth or by caries. In both cases the dentinal fibrils are subject to irritation, and this irritation determines the deposition of lime salts in the substance of the pulp. When once such a deposition begins, it tends to increase till the pulp is changed from a highly sensitive living organism to one practically lifeless, without nerves or vessels, and without the system of tubules which exists in the dentine. During the course of calcification quite severe pain may arise, evidently due to the pressure of the calcareous masses upon the nerve-filaments.

A pathological change similar to that occurring in calcification of the pulp is that which takes place in the formation of secondary dentine. This formation is found on the periphery of the pulp at a place adjacent to a carious cavity, and is deposited by the odontoblastic layer of the pulp, which is the formative agent in normal dentine. Secondary dentine is evidently a means taken by

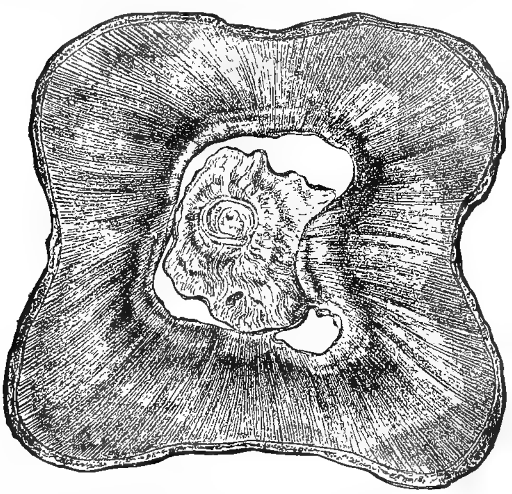

FIG. 3797.—A Section across the Neck of a Molar, showing a Growth of Secondary Dentine in the Pulp-cavity.

nature for the protection of the pulp against the injurious influences incident to advancing caries. Secondary dentine is similar in structure to normal dentine, containing, like it, tubules and fibrils. Its formation is, however, somewhat less regular, and in case the secondary dentine extends far toward the interior of the pulp, it loses its supply of dentinal tubes and becomes less like dentine, and more like a calcified pulp. While the formation of secondary dentine in the neighborhood of decay undoubtedly tends for a time to prolong the life of the pulp, experience seems to show that secondary dentine, when once deposited, tends to increase to such proportions as in the end to destroy the life of the pulp.

The process just described is to be distinguished from that deposition of dentine which takes place by degrees during the whole life of the tooth. This deposit is very slow in formation, and takes place uniformly around the inner side of the whole pulp-cavity. By this physiological deposition of dentine the pulp-cavities in the teeth of old people are reduced to very small proportions. This seems to indicate that the pulp is useful and necessary inversely to the age of the tooth.

There remains to be mentioned a pathological change which increases the size of the pulp. Such an increase can occur only in case the pulp has been exposed. Let such a pulp be subjected to the irritation of foreign substances, and likewise to that of the sharp edges of a carious cavity, and it will sometimes proliferate and fill the cavity.

Why the pulp does not become inflamed and destroyed under such circumstances cannot be explained. This process has usually been noticed in the case of young teeth. The growth may assume the size of a pea, or be larger. It is of fleshy consistency, and is organically united to the pulp by a narrow pedicle, hence it is called polypus of the pulp. In microscopic examination it is found to consist of numerous round and spindle-shaped cells, interspersed with fibrous tissue, and an epithelial covering has been described by some writers. Its blood-vessels pursue a tortuous and irregular course, unlike those in the pulp. No nerves have been found in this tumor, yet it is slightly sensitive to touch, resembling the gum in this respect. Sometimes a mucopurulent discharge issues from its periphery. A polypus protects the pulp against external violence. It is extremely tenacious of life, and will grow again if cut off.

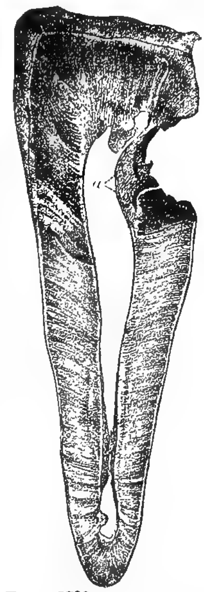

FIG. 3798.—An Incisor Tooth affected with Caries. *a*, A deposition of secondary dentine about the cavity of decay.

A growth similar to a polypus takes place in some cases of fractured teeth. The pulp having been exposed, proliferates through the openings caused by the fracture and forms a tumor outside the pulp-cavity. This tumor, morphologically, resembles a true polypus of the pulp; it has, however, a nerve-supply, and is quite sensitive to the touch, thus differing from a polypus. Salter has named this growth a "sensitive sprouting of the pulp."

Under pathology of the dentine the most important process to consider is caries. This process affects the enamel and cementum as well as the dentine, but has more to do with the dentine than with the other tissues. In the first place, it may be said that caries of the teeth does not resemble caries of bone. The term caries as applied to the teeth is a misnomer, given at a time when the true nature of the process was not understood. However, the term has become so generally used that it cannot now be easily dropped. The pathological change which occurs in caries is a decalcification and disintegration of the several tissues of the teeth. The latter condition follows very quickly upon the former, on account of the large proportion of earthy constituents existing in the parts attacked. Caries may affect any of the teeth of either dentition, but it affects certain teeth more frequently than others. Magitot has tabulated ten thousand cases of caries occurring in the permanent teeth, and his tables show that the tooth most liable to caries is the first lower molar, after which follow in succession the first upper molar, the second lower molar, first upper bicuspid, second upper bicuspid, upper lateral, second upper molar, upper central, second lower bicuspid, upper canine, first lower bicuspid, upper wisdom, lower wisdom, lower canine, lower central and lateral. Caries not only shows a preference for certain teeth rather than for others, but it also shows a preference for certain parts of individual teeth rather than for other parts. Those surfaces of the teeth which are smooth and kept clean by the motions of the tongue, lips, and cheeks, are not attacked by caries; while surfaces presenting an uneven contour, abounding in pits and fissures, are its favorite seat. Hence, we find it located in the crowns of the molars and bicuspids, in the pits on the lingual surfaces

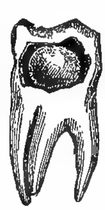

FIG. 3799.—Polypus of the Pulp occupying the Cavity produced by Caries.

of the six superior front teeth, and on all approximal surfaces which, though not uneven, are not cleansed by the motions of the mouth. The buccal and labial surfaces of the teeth, just at the margin of the gum, are likewise often the seat of caries. Caries manifests its presence by a change of color in the tissues attacked. This change may be merely from translucency to opacity, or to a variety of colors ranging from yellow to brown, and even black; sometimes a gray or bluish-gray is seen. As a rule, the slower the progress of the disease the deeper the color of the affected parts, and conversely, the more rapid its progress the lighter the color of the affected parts. Caries usually attacks the enamel first, though it may begin with the cementum. It starts in a small pit or fissure, where soon the enamel is found to have lost its peculiarly hard and dense surface. Instead of resisting the most highly tempered steel instruments, as does normal enamel, it crumbles away under slight force. Thus a small opening is made through the enamel to the dentine. This opening may be as large as the head of a pin, or it may be very minute. During this process the enamel has become decalcified and disintegrated. Some authorities say that the centre of the enamel prisms are first affected, and others that the interprismatic substance is first destroyed, in consequence of which the prisms separate and fall to pieces. When once caries has perforated the enamel it no longer confines itself to a narrow area, but spreads out laterally between the enamel and dentine. The degree of lateral extension varies greatly, but seems to be somewhat dependent on the structure of the dentine. If the dentine is well calcified, and with few interglobular spaces, the lateral extension is not so great as when the dentine is imperfectly calcified and abounding in interglobular spaces. The carious process in its lateral extension seems to follow the anastomoses of the dentinal tubules, which are very abundant at the junction of the dentine and enamel. After having affected a certain area on the periphery of the dentine, caries penetrates its substance, following the tubules toward the pulp. Inasmuch as the tubules converge

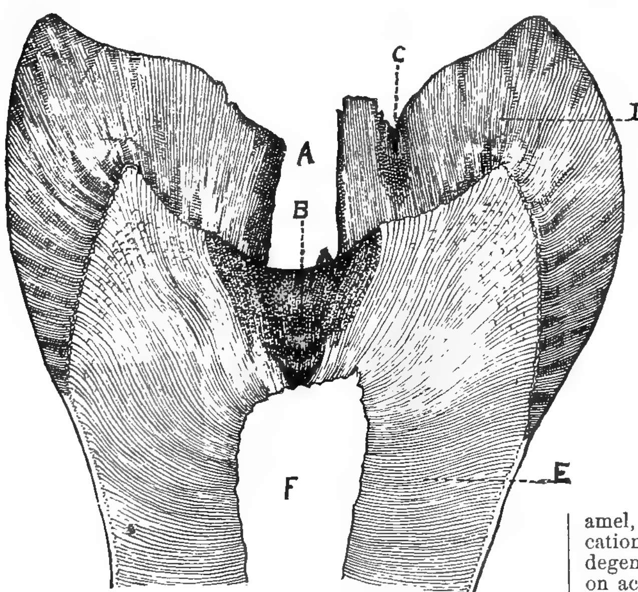

FIG. 3800.—Microscopic Section through a Carious Cavity occurring in a Molar Tooth. A, the initial opening through the enamel; B, the cone-shaped area of decay—the affected tissue being discolored and somewhat softened, but not disintegrated; C, a minute pit in the enamel where caries has just started; D, the enamel; E, the dentine; F, the pulp-cavity.

from the periphery of the dentine toward the pulp-cavity, the progress of caries is marked by a cone-shaped area, the large end of the cone being in the periphery of the dentine, and the small end pointing toward the pulp. Caries tends to penetrate the pulp-cavity, and rarely fails, unless checked by mechanical means. When once the pulp-cavity has been penetrated, the pulp is exposed to the degenerative changes already described, and,

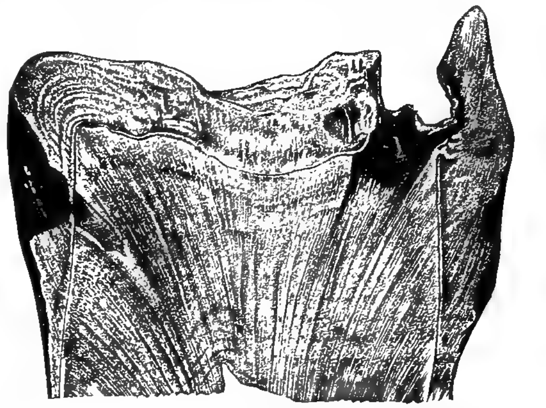

FIG. 3801.—Microscopic Section through a Molar Tooth affected with Caries. The darkly shaded portions represent a brown discoloration.

as a rule, dies and disintegrates. The carious process then invades the pulp-cavity, meanwhile spreading laterally through the dentine from the area originally attacked, and disintegrating the enamel from the under side. By degrees the crown of the tooth becomes so hollowed out by the continuous softening and disintegration of the dentine that the shell of enamel left becomes unable to withstand the force of mastication, and consequently is broken away. Nor does caries stop with the destruction of the crown, it continues its work in the root, enlarging the root-canal at the expense of the surrounding root-substance until the root becomes a mere shell, and is finally entirely disintegrated. The carious process in the root is not so rapid as in the crown, and roots may withstand its action for years.

The microscopic examination of the carious process shows the change in color of the affected parts which has been described, and the disintegration of the enamel rods. The tubules of the dentine appear enlarged in calibre; and their size increases as the process advances. The intertubular substance diminishes with the enlargement of the tubules, and finally disappears with the confluence of adjacent tubules. Micro-organisms are found in great numbers within the tubules.

In the cement, the carious process is similar to that found in the dentine. The lacunæ and canaliculi are enlarged at the expense of the surrounding tissue, which softens and breaks down as the process advances.

Micro-organisms are present as in carious dentine.

A chemical change to be especially noted in connection with all the tissues affected by caries, is the acid reaction which is invariably present.

Etiology of Caries.—There are certain predisposing causes upon which all are agreed; of such may be mentioned a faulty calcification of the enamel, which leaves the dentine exposed; a faulty calcification of the dentine, which leaves it less able to resist degenerative changes; a crowded condition of the teeth, on account of which it is difficult to keep the spaces between the teeth clean.

With regard to the exciting or immediate causes of caries, there has been great diversity of opinion. Of the ancient pathologists, some ascribed caries to a disturbance in the "humors of the body." Others regarded it as due to the ravages of worms which infested the oral cavity.

When we come to observers of scientific repute, we find that the older ones held to a vital or inflammatory theory. According to them, the disease began from

within, by an inflammatory process of the dentine or pulp, the process in dentine resembling caries of bone; hence the term caries was applied to it also.

The vital theory of caries has been effectually disproved by the fact that when natural teeth have been mounted upon artificial plates, and thus worn in the mouth, they have been subject to caries precisely resembling the caries of the teeth normally situated in the jaw.

By others, caries was considered to be a sort of gangrene, due to a disturbance in the nutrition of the dentine.

When, however, the secretions of the mouth came to be studied with reference to their possible agency in producing caries, and when they were found to be at times acid, and when, also, the acid fermentations occurring in the mouth came to be studied in this connection, there was developed what is called the acid theory of caries. According to this theory, caries originates from without and not from within, as those holding the vital theory claimed. The active agency in producing it is acids, which are always present in the mouth, due either to acid secretions or acid fermentations. These acids are to a large extent, it is true, neutralized by the alkalinity of the normal mixed saliva; but in some places, as in the crowns of molars and in the spaces between the teeth, the acid secretions are so protected from the neutralizing influence of the saliva that they are able to retain their reaction and attack the enamel, decomposing the phosphate of lime and other mineral constituents, of which it is largely composed. Having penetrated the enamel, the acids act in a similar manner upon the dentine. According to this theory the tissues of the tooth are affected by chemical decomposition, as if there were no vital element whatever concerned. To substantiate this view many experiments were made, by subjecting extracted teeth to the influence of a weak acid solution imitating conditions found in the mouth. Teeth thus treated underwent a softening and decalcification similar to that found in the mouth in the case of caries. The point was thus well established that caries consisted in the decalcification and disintegration of the mineral constituents of the teeth by an acid.

While some have held a vital theory to account for caries, and others an acid theory, still others again have taken middle ground and held a chemico-vital theory.

The discovery of the presence of micro-organisms in the tubules of dentine affected by caries was an important step in advancing our knowledge of the process. The name of leptothrix buccalis was given to these organisms when first discovered. Though their true agency in caries was not at once understood, they were considered to play an important rôle. During the last few years, however, extensive investigations have been made to determine more accurately the nature of the micro-organisms found in the mouth, and their relation to the process of caries. The most valuable of these investigations have been conducted by Dr. W. D. Miller, of Berlin. His method has been to infect sterilized culture media of various kinds with neutral saliva or with neutral carious dentine, and he has found, invariably, that, when the culture medium contains sugar, an acid is produced. By successive cultures he has isolated the organisms which produce the acid. Of the organisms he writes as follows: "We have, then, in carious dentine, two distinct fungi—one always, the other often, present; the former surely, the latter probably, producing lactic acid from sugar" ("American System of Dentistry," vol. i., p. 803). Perfectly sound dentine, subjected to a pure culture of the fungi just mentioned in a medium containing sugar, underwent, in course of time, typical caries. According to Dr. Miller—and his theory is now quite generally accepted—the history of caries is as follows: It starts wherever, from the contour of individual teeth or from the relation of one tooth to another, a collection of food is possible. In every such collection are multitudes of micro-organisms which are capable of thriving in the presence of sugar, and of decomposing this substance and forming lactic acid. This acid decalcifies the enamel and forms a small pit which, being constantly filled with food, offers a favorable nidus for the continued growth of the same organisms. When the enamel has been penetrated, the organisms begin to multiply in the tubules of the dentine, and there continue the decomposition of sugar absorbed from the mouth. The resulting lactic acid enlarges the tubules by the decomposition of the mineral constituents of the dentine. According to this theory, the secretions of the mouth have very little to do with the production of caries. It is possible that at one time the secretions of the mouth may be more unfavorable to the life of micro-organisms than at another, since it is well known that, at certain times and in certain individuals, caries progresses very rapidly.

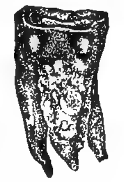

Fig. 3802.—Nodular Hypertrophy of Cement in the case of a Superior Molar Tooth.

A condition resembling caries, and yet essentially differing from it, is erosion. Erosion is commonly found on the labial surface of the six anterior teeth, either at the margin of the gum, or between it and the cutting edge. It also sometimes affects the bicuspids and molars. Erosion produces shallow cavities, which involve the enamel and penetrate to the dentine. These cavities are larger at their external opening than in their deeper parts, and are smooth, hard, and polished throughout. They present neither the characteristic softening nor undermining growth which are found in caries. The cavities do not rapidly enlarge, but may become of such size as to threaten the life of the pulp. Caries is sometimes superadded to erosion, thus modifying the course of the destructive process. The etiology of erosion is obscure; but it is usually assigned, in lieu of a more probable cause, to the effect of acid mucus.

Pathological Changes in the Cement.—The most common pathological change of the cement is an hypertrophy, which is due to an irritation of the peridental membrane. This membrane, lying between the cement of the root and the bony alveolus, is at once the formative membrane of the cement of the tooth and of the adjacent bone of the alveolus. When, however, the cement of the root has been completed, the activity of the peridental membrane, so far as its cement-forming function is concerned, normally ceases. It does not resume this function unless subjected to irritation, in which case it may deposit additional cement upon the root in various ways. The deposit may be diffuse, covering the entire root, though most abundant at the apex. It may be nodular, the nodules being found at any point on the root, and being of various sizes: or it may consist of a club-shaped enlargement at the end of the root.

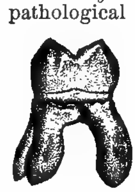

Fig. 3803.—General Hypertrophy of the Cement about the Roots of a Superior Molar Tooth.

The added cement is similar in structure to the primary cement, the union between the two deposits being, as a rule, not noticeable. In certain cases, however, blood-vessels penetrate this secondary deposit of cement, a condition not found in the primary deposit. Hypertrophy of the cement has never been observed in the case of the temporary teeth, and affects the permanent teeth during adult life. The teeth most commonly involved are the upper bicuspids and molars, though the others are not exempt. Hypertrophies of the cement are called hypercementoses, osteomata, and exostoses. Of the causes which produce an irritation of the peridental membrane, and consequent hypertrophy of the cement, perhaps the most frequent is caries with its sequelæ, viz., inflammation and death of the pulp, with extension of the inflammation to the peridental membrane. Another cause is the undue pressure which teeth are sometimes subjected to in the process of occlusion and mastication. This arises when many of the teeth have been lost and the few remaining ones are compelled to bear all the strain of service. In such cases the peridental membrane is over-

Fig. 3804.—Hypertrophy of the Cement about the end of the Root of a Bicuspid Tooth.

worked, literally crowded to the wall, and in consequence may become irritated. The same effect may be produced by the insertion of fillings which project from the crown of a tooth so far as to concentrate the force of occlusion on the filled tooth. While hypertrophy of the cement is commonly due to irritation from undue force, there are cases in which teeth having no antagonists are found to have hypertrophied cement. The symptoms which may arise from an hypertrophy of the cement are caused by the pressure of the new-growth upon the nerves of the peridental membrane and upon the nerves of the pulp at the apical foramen. Many cases of hypertrophy exist which occasion no symptoms, the condition becoming known only after extraction. In old people it is usual to find the cement somewhat thickened, and this change can almost be called physiological, so constantly does it occur. Doubtless the process is so gradual that the surrounding tissues accommodate themselves to the enlarged root, and their nerves are subjected to no irritation. In other cases pain is an important and persistent symptom. The pain may be localized and accompanied by a soreness in the socket, or it may be diffused throughout the jaw or reflected to adjoining parts of the head. Severe neuralgias of the head, face, and neck have been found to owe their origin to the hypertrophy of the cement of a tooth. The tooth may appear to be perfectly sound, in which case it is exceedingly difficult to locate the source of the pain. When, however, neuralgias exist in connection with teeth which, though not carious, are the seat of pain or are sore in the socket, it is fair to suspect either an hypertrophy of the cement or a calcification in the pulp. Not only does an enlarged cement cause severe neuralgic pains about the head and face, but cases of epilepsy and insanity have been reported as due to the same cause. A case from Tomes' "Dental Surgery" is in point. "A lad, a farm-laborer from Windsor, was admitted into the Middlesex Hospital for epilepsy. The usual remedies were tried for six weeks without effect. His mouth was then examined and the molar teeth of the lower jaw found to be much decayed, the fangs of some alone remaining. Although he did not complain of pain in the teeth or in the jaw, the decayed teeth were removed, and the fangs of each were found to be enlarged and bulbous from exostosis. During the eighteen months that succeeded the removal of the diseased teeth, he had not suffered from a single fit, though for many weeks previous to the operation he had had two or three per day."

A second pathological change of the cement is absorption. This is often found in connection with hypertrophy, and occurs at scattered points and produces depressions in the surface of the cement. In cases of long-continued inflammation about the apex of the root, the cement is likely to be in part absorbed, giving a rough outline to the apex.

Pathology of the Peridental Membrane.—Disease of the peridental membrane may be due to a constitutional disturbance, or to pathological affections of the pulp, or may be dependent upon, or associated with, calcareous deposits upon the root of the tooth. Of the constitutional affections which react upon the peridental membrane, Tomes enumerates rheumatism, syphilis, and the exhibition of mercury.

Inflammation of the peridental membrane from rheumatism is independent of caries, and may involve one or more teeth. The inflammation is distributed over the entire membrane, causing a loosening of the tooth and a soreness in the socket. Its course is subacute or chronic, does not tend to abscess, and is amenable to constitutional treatment.

Inflammation of the peridental membrane from syphilis is chronic. Pus may be discharged around the neck of the tooth, which becomes sore in the socket and loose. If the disease is unchecked the teeth may fall out of their own accord, owing to a complete destruction of the peridental membrane. Associated with this process there often occurs a necrosis of the surrounding bone.

Inflammation from the administration of mercury, whether in the treatment of syphilis or not, is associated with ptyalism, and is of a subacute or chronic character. The teeth become loosened and sore in their sockets, and, if the drug is long continued, a discharge of pus around the neck of the teeth and final loss of the teeth may result.

The effect of phosphorus upon the peridental membrane, though not belonging strictly under constitutional affections, is of great interest. Persons subjected to the fumes of phosphorus, as are those who work in match factories, often have necrosis of the maxillary bones. This necrosis starts with an inflammation of the peridental membrane, which is very sensitive to the irritating fumes of phosphorus. As a result of inflammation the membrane is destroyed, and the bony alveolus being thus cut off in large degree from its source of

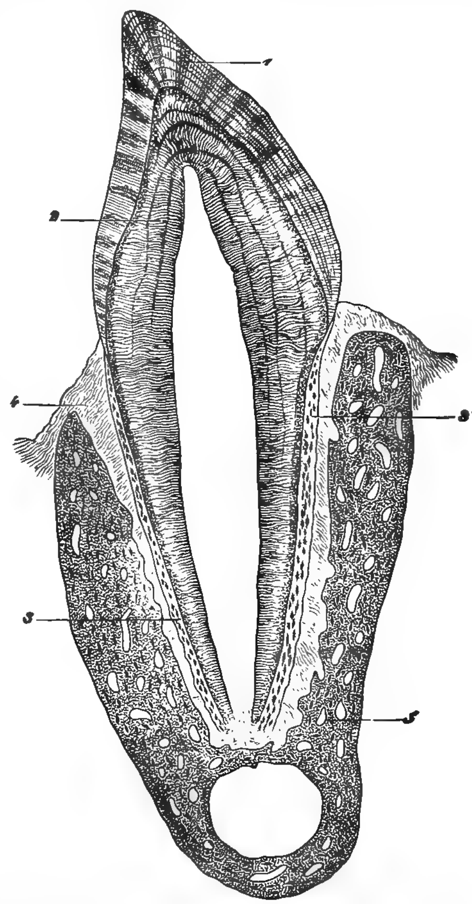

FIG. 3805.—The Relation between the Root of a Tooth, its Peridental Membrane, and its Bony Socket. 1, The enamel; 2, the dentine; 3, the cement; 4, the peridental membrane, which is also the periosteum of the socket; 5, the bony socket.

nourishment, necrosis is invited. It has been found that this disease mainly affects operatives in whose mouth are carious teeth, or who have had teeth extracted while pursuing their occupation. The phosphorus fumes enter a carious cavity and reach the peridental membrane by way of the apical foramen. If, however, the teeth are sound and the gums healthy, phosphorus has little if any destructive effect in the mouth.

Pathological affections of the peridental membrane consequent upon disease of the pulp are of frequent occurrence. When the pulp has become severely inflamed it is common to find, in addition to the symptoms attendant upon simple inflammation of the pulp, a soreness of the tooth in the socket. If the tooth is then percussed with a steel instrument the patient will flinch. This is an indication that the inflammation has proceeded up the root-canal and extended to the peridental membrane situ-

ated around the apex of the root. Symptoms pointing to inflammation around the root do not always appear during the inflammatory stage of the pulp; they more commonly follow its death and putrefaction. When this has occurred, irritating products of decomposition, both gaseous and liquid, pass up through the canal and set up acute inflammation in the membrane at the apex of the root. In the light of our knowledge of the agency of micro-organisms in inflammatory processes, we must consider that the germs, which were active in producing inflammation of the pulp, are also active in the consequent inflammation of the peridental membrane. This membrane being of connective tissue, and richly supplied with blood-vessels, is an excellent field for inflammatory action, and being closely confined between unyielding walls, and having an abundant nerve-supply, is capable of producing symptoms of the severest character. When an inflammatory process has started at the apex of the root, the tissues become swelled and engorged with blood, the condition extending from the apex toward the neck of the tooth. In consequence of the swelling of the membrane, the tooth is pushed slightly from its socket and becomes loose. The clinical symptoms are ushered in by a dull, continuous pain, which is not occasioned by changes of temperature, as is often the case with inflammation of the pulp. The tooth upon pressure feels sore in the socket, yet, during the first stages of the inflammation a grinding of the affected tooth against its antagonists gives some relief. The inflammatory process sometimes stops at this point, but very often goes on to the formation of an alveolar abscess.

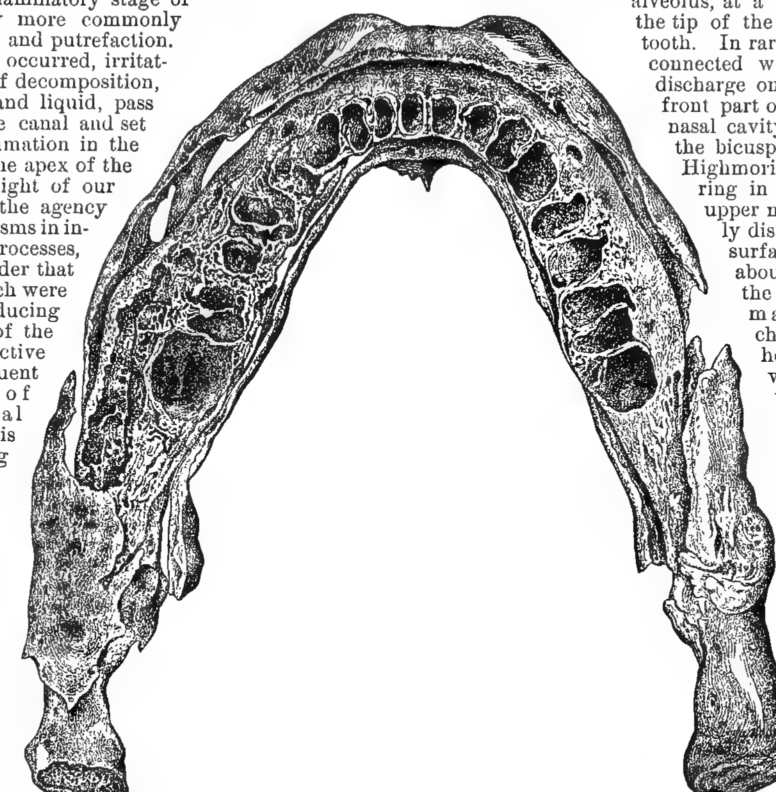

FIG. 3806.—Phosphor-necrosis of the Lower Jaw.

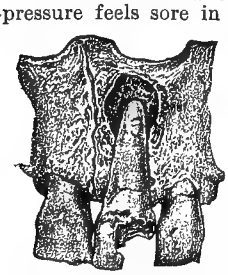

FIG. 3807.—Absorption of Bone, produced by an Alveolar Abscess at the Tip of the Root of a Left Superior Incisor.

Alveolar abscess forms about the tip of the root. As pus collects, the neighboring bony tissue is absorbed, and a cavity is formed varying in size according to the severity of the inflammation. Like abscesses in other parts of the body, it seeks an outlet at the point of least resistance. There are several ways in which the pus may make its escape. It may penetrate the bony alveolus in a line which is, roughly speaking, at a right angle to the root of the affected tooth, and thus make its escape into the mouth, or, in some cases, upon the face. Or it may pass down the length of the root, either between the peridental membrane and the cement, or between the peridental membrane and the bony socket, in both cases discharging about the neck of the tooth. When an alveolar abscess occurs in connection with the six anterior teeth and bicuspids of the upper jaw, it usually discharges on the labial surface of the alveolus, at a point about opposite the tip of the root of the affected tooth. In rare instances an abscess connected with these teeth may discharge on the outside of the front part of the face or into the nasal cavity, and in the case of the bicuspids, into the antrum Highmorii. An abscess occurring in connection with the upper molars most commonly discharges on the buccal surface of the alveolus, about opposite the tips of the roots affected. It may, however, discharge in the neighborhood of the hard palate, when proceeding from the palatal root. Besides these usual points of discharge, the abscess may open into the antrum or upon the outside of the face near the union of the malar and superior maxillary bone. Abscesses formed about the lower anterior teeth usually open on the labial side of the alveolus, within the mouth. They may, however, open on the outside of the face, below the horizontal portion of the jaw. Abscesses in connection with the lower bicuspids usually open on the buccal side of the alveolus, though they may discharge on the face, along the body of the jaw. Abscesses connected with the lower molar teeth usually find exit upon the buccal side of the alveolus, but sometimes on the outside of the face, adjoining the inferior maxillary bone. Cases are reported in which the abscess has opened in the neck, and even as low down as the infraclavicular region. Alveolar abscesses usually assume a chronic condition, and keep up a discharge of pus from their fistulous opening as long as the root in connection with which they have been formed remains in the mouth, or until the pulp-canal of the root has been properly cleaned and filled. The opening of an alveolar abscess upon the face or neck has oftentimes been mistaken for the discharge from necrosed bone. A case coming under the observation of the writer, while in charge of the Dental Infirmary of the Harvard Dental School, will illustrate the point. A farmer, from the western part of Massachusetts, came to the Massachusetts General Hospital to

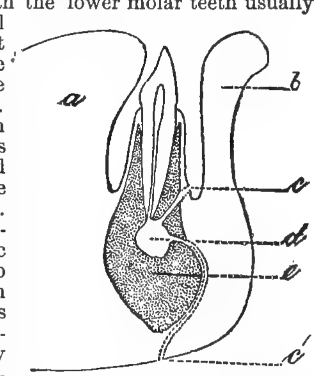

FIG. 3808.—A Vertical Section through a Lower Incisor and surrounding Parts, illustrating two ways in which an Alveolar Abscess may find vent. The first, and more common, way, is by the fistula opening at *c*; the second, and less common, way, is by the fistula opening at *c'*. *a*, the tongue; *b*, the lower lip; *d*, the abscess cavity; *e*, the inferior maxillary bone.

be treated for a fistula opening at the symphysis of the lower jaw. The fistula discharged more or less, and was thought to be due to necrosis of the lower jaw. The condition had existed for about two years, and had been treated by injecting the fistula with various medicaments. At the hospital they declined to operate till his teeth had been examined. Such an examination showed a lower incisor which, though not carious, was believed to contain a dead pulp and to be the origin of the fistula. The tooth was extracted at the Dental Infirmary, and the patient advised to return home and report in a month's time. In due time the patient reported that the fistula had completely healed. While not all cases of fistula about the face are due to dental abscess, yet the teeth should always be examined when such a case presents itself.

The clinical symptoms attendant upon alveolar abscess are well marked and of peculiar severity. Since alveolar abscess starts with simple inflammation of the peridental membrane, the first symptoms are the same as those described under that affection. As the condition advances, however, the pain becomes more intense, the tooth is farther protruded from its socket, and is exquisitely sensitive, the touch of a finger often being sufficient to produce great agony. Sometimes the formation of pus is marked by a chill and rise of temperature. This formative stage may last from twenty-four to forty-eight hours; meanwhile the pus has been working its way through the surrounding bone into the soft parts. When this has occurred the face in the neighborhood of the affected tooth becomes swollen, and there is a marked remission of pain. The mucous membrane of the gum about an alveolar abscess is much congested and swollen, besides being sore to the touch.

As peridental inflammation and alveolar abscess are very common causes of toothache, it is necessary to distinguish between the toothache so caused and that due to irritation of the pulp. Toothache from irritation of the pulp is started by the pressure of food against the pulp, by a sudden variation of temperature, or by sweet or salt substances. The pain is violent, but intermittent, and no soreness of the tooth in the socket, as a rule, exists. Toothache from inflammation of the peridental membrane or alveolar abscess is started by the death and decomposition of the pulp. The pain is continuous; it is increased by the application of heat, diminished by the application of cold. The tooth is sore in the socket, and if the crown is tapped with an instrument the patient will flinch. The tooth is protruded from the socket, the gums are inflamed, and the face swollen.

The treatment of peridental inflammation or alveolar abscess is, first, to remove the cause of the irritation. If the tooth is without value to the individual it should be extracted. This is the quickest way out of the difficulty. If, however, it is desirable to preserve the tooth, its pulp-cavity should be at once opened and cleansed from all decomposing material. If this is done in the first stage of the difficulty it is usually sufficient, and, the source of irritation being removed, the inflammation subsides. If the case be one of alveolar abscess the cleansing of the pulp-cavity is of advantage, not only in removing the source of irritation, but also in giving a vent to the forming abscess through the root-canal. In many cases, however, the abscess will open through the alveolus in spite of treatment. Such an opening can sometimes be hastened by incising with the lance over the affected root. Whether pus can be reached with the lance or not, the incising of the gum gives relief by diminishing the congestion of the part. The use of leeches upon the gum is an old and often effective remedy. The tincture of iodine painted upon the gum is of common use; also the application of capsicum plasters, slippery-elm poultices, and roasted raisins. A poultice should never be applied to the outside of the face, on account of the danger of causing the abscess to discharge externally and leave a scar upon the face which is a permanent disfiguration.

Pathological Affections of the Peridental Membrane dependent upon, or associated with, Calcareous Deposits on the Teeth.—Calcareous deposits are of two classes: those originating from the saliva, and called salivary tartar or salivary calculus, and those originating apparently from a serous exudation from the peridental tissues, and called serumal calculus. The salivary tartar is composed mainly of phosphate and carbonate of calcium, which are contained in the saliva and are precipitated upon the teeth. It is found in greatest abundance on the buccal sides of the upper first molars, near the opening of the parotid gland, and on the lingual side of the lower anterior teeth, near the opening of the submaxillary and sublingual glands. Salivary calculus is first deposited at the neck of a tooth, and, if not removed, spreads both toward the cutting edge and in the opposite direction up the root. In its progress along the root it presses away the gum from the neck of the tooth and separates the peridental membrane from its attachment to the cement. If allowed to rest in contact with the peridental membrane, it destroys its life, and also that of the adjacent bony alveolus, thus largely diminishing the natural support of the tooth. In this way the teeth affected become loosened, and may be entirely dislodged. Salivary calculus, though, as a rule, limited to the regions described, may in much neglected mouths cover the entire lingual side of the lower teeth and the buccal sides of the upper teeth. The treatment of this deposit consists in its removal, after which the peridental membrane quickly resumes its normal character, except such portions as have been destroyed, and the gum closes around the neck of the tooth.

The second form of calcareous deposit, called the serumal, has nothing to do with the saliva, nor is it limited to certain localities in the mouth. It is supposed to be due to a deposition from serum exuded from the gingival margin of the gum and peridental membrane; this deposition taking place in consequence of irritation. It may affect any of the teeth, and is located at the margin of the gum, often hidden from sight. In color it varies from yellow to brown, and even black. It often encircles the root of the tooth, but may be deposited in patches. It increases slowly, but is destructive to the peridental membrane, which becomes separated from the root. The alveolar bony processes about the neck of the tooth are in time absorbed, and the natural support of the tooth is diminished.

In connection with this deposit there may be a flow of pus, due to irritation of the peridental membrane. To this condition the name pyorrhœa alveolaris has been given. While salivary calculus causes the loosening and falling out of the lower front teeth, the serumal deposit may effect the loosening and falling out of any of the teeth, and is the most common cause of that result.

There remains to be described an affection of the peridental membrane which is very destructive to that tissue. It is usually associated with a deposit of serumal calculus, and may be very similar to the affection just described. The calcareous deposits are, however, more likely to be in patches, and to advance more rapidly to the apex of the root. By this means pockets are formed along the side of the root, due to a separation of the peridental membrane from the cement of the root. In the first form of serumal deposit the peridental membrane is separated from the tooth around the entire circumference of the root, and from its neck as far up as the deposit reaches; the tips of the root, meanwhile, being firmly attached to the peridental membrane until the tooth falls out. In the second form, however, the root may be separated from its peridental membrane on one side up to its apex, and in other parts firmly attached. At the apex the root is often entirely separated from its surrounding membrane, though at its neck there may be a fairly good union. Whether the deposit of calculus is due to the inflammation of the peridental membrane, or the inflammation is due to the deposit of calculus, is not decided. This form of calculus is associated with a flow of pus and rapid destruction of the peridental membrane. This membrane having been destroyed, the tooth loses its hold in the socket, and in time drops out. There is some reason to suppose that this disease is due to a special micro-organism, and that it is infectious. On this account it has been called infectious pericementitis.

The term pyorrhœa alveolaris is commonly applied to this as to the preceding condition. The treatment of both kinds of serumal calculus with associated inflammation of the peridental membrane is to remove the deposits of calculus and to keep them removed. To this must be added thorough cleanliness of the teeth, and a washing out of all pockets around the necks of the teeth produced by the separation of the root from its membrane. The use of antiseptic fluids in such pockets is a desirable and effective treatment, especially in that form of deposit last described. In people of middle or advanced life calcareous deposits are more destructive to the teeth than is caries.

The pathological condition commonly described by the term a "dead tooth" is one which needs explanation. When the pulp of a tooth dies the tooth is often called a dead tooth. The term thus applied is incorrect and misleading. When the pulp dies it is true that the main source of nourishment for the tooth has been cut off; but, while the peridental membrane is alive and healthy the tooth still receives nourishment from it. That this membrane can nourish the dentine is evident from a reference to the plates on dental anatomy, where the dentinal tubules are shown to connect with the granular layer of the dentine, and the granular layer to be in connection with the canaliculi of the cement. The cement is nourished by its periosteum, which is the peridental membrane. A pulpless tooth is not necessarily, nor is it usually, a dead tooth. If its peridental membrane is in a healthy condition, and its root-canals thoroughly cleaned and filled, it may be as comfortable and as useful an organ as a tooth having a pulp.

When, however, both the pulp and peridental membrane—the two sources from which a tooth gets its nourishment—have been destroyed, then the tooth is dead, and is a foreign body which nature quickly rejects.

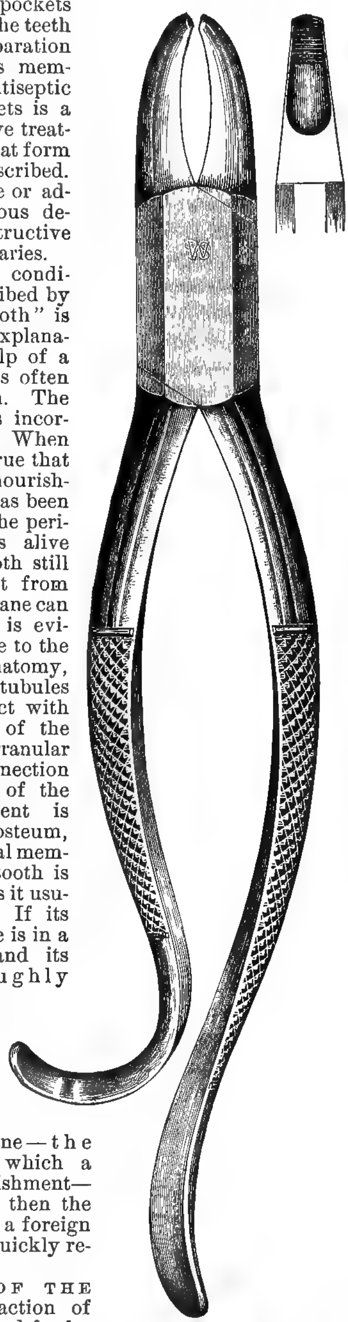

FIG. 3809.*—Forceps No. 13. Incisor, Upper. Also made with straight handles.

EXTRACTION OF THE TEETH.—The extraction of the teeth may be called for by various conditions, of which the more common are:

1. A crowded condition of the teeth which threatens or has caused irregularity. Teeth may be placed entirely outside or inside of the dental arch. The extraction of such teeth is often advisable. It may, however, be laid down as a rule that the superior canines and central incisors should not be extracted to correct irregularity; nor should the inferior canines, except in rare instances. For example, it often happens that when the superior canines make their appearance through the gum there is no room for them between the superior lateral incisors and first bicuspids. As the canines descend they in consequence take a position outside of the arch and are a deformity. They are not on this account, however, to be removed, because by their position and size they give character to the expression of the face. A bicuspid, or sometimes a first molar, should be extracted instead, and thus room gained for the canine. In many such cases, however, there is no need for extraction, inasmuch as the enlargement of the dental arch, either by nature or by mechanical appliances, will furnish the required room.

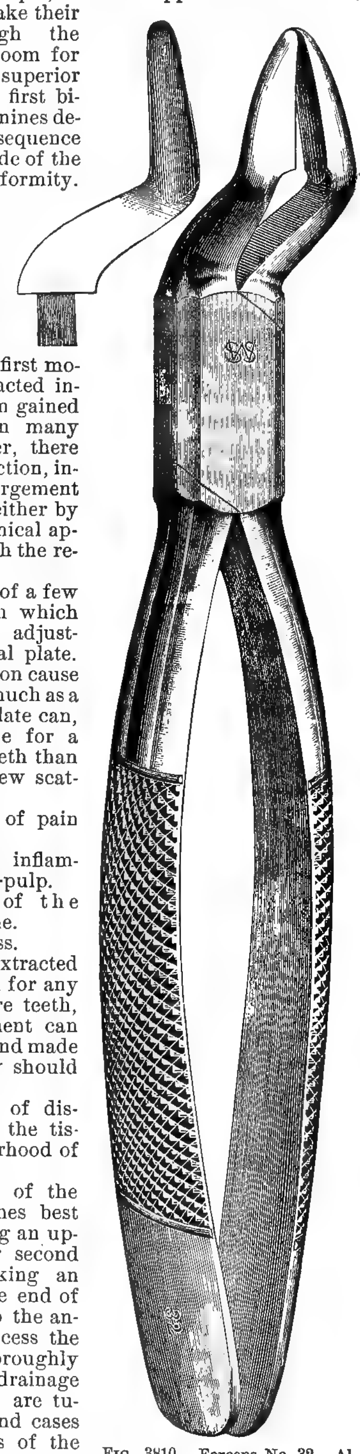

FIG. 3810.—Forceps No. 32. Alveolar, Bayonet Shape.

2. The existence of a few teeth in the mouth which interfere with the adjustment of an artificial plate. This is a very common cause for extraction, inasmuch as a more satisfactory plate can, as a rule, be made for a mouth having no teeth than for one having a few scattered teeth.

3. The existence of pain due to:

a. Congestion or inflammation of the tooth-pulp.

b. Inflammation of the peridental membrane.

c. Alveolar abscess.

More teeth are extracted to relieve pain than for any other cause. Where teeth, however, by treatment can be relieved of pain and made useful organs, they should not be extracted.

4. The existence of diseased conditions of the tissues in the neighborhood of the teeth.

An inflammation of the antrum is sometimes best treated by extracting an upper first molar or second bicuspid and making an opening through the end of the root-socket into the antrum. By this process the antrum can be thoroughly cleansed and good drainage established. There are tumors of the jaw, and cases of caries or necrosis of the maxillary bones, which necessitate a removal of teeth.

5. The persistence of the temporary teeth when the permanent teeth are about to erupt.

It may be laid down as a rule that the temporary teeth

* The forceps are numbered according to the catalogue of the S. S. White Dental Manufacturing Co., published in August, 1887.

should not be removed until the permanent teeth are ready to take their place. When this condition exists the roots of the temporary teeth have been for the most part absorbed, and the crowns have become loose. While the above rule should be adhered to as far as possible, yet there are cases in which severe inflammation connected with the temporary teeth requires their premature extraction.

The process of extraction and the instruments employed vary greatly with the different teeth in the mouth. A knowledge of the number, shape, and size of the roots of the teeth is necessary to insure success in their re-

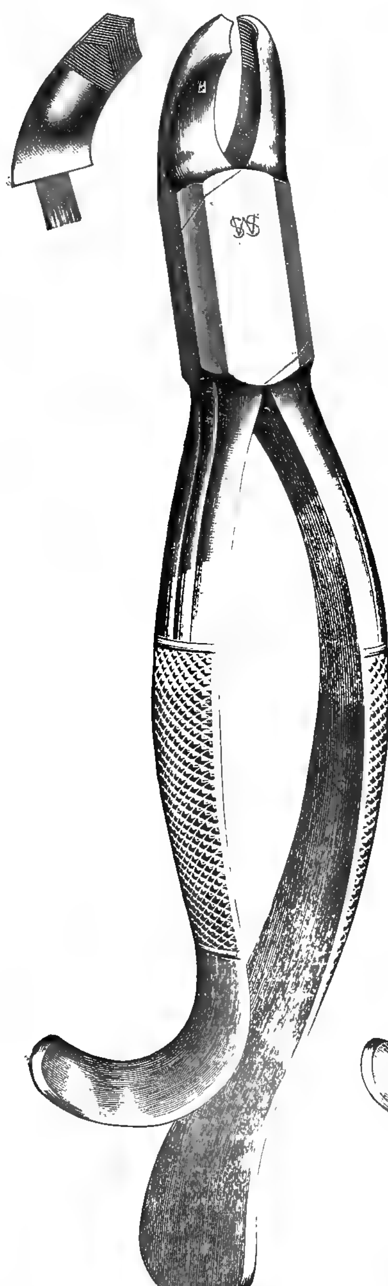

Fig. 3811.—Forceps No. 18. Molar, Upper. Right Side.

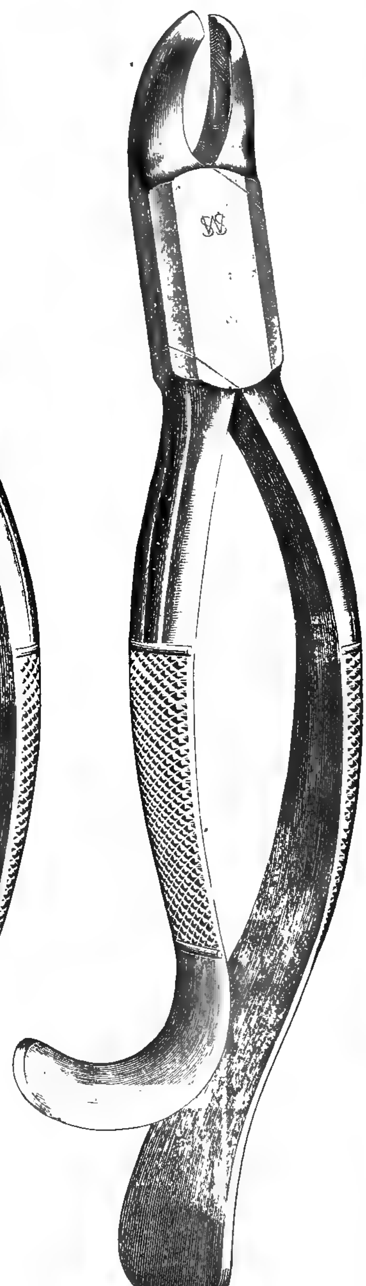

Fig. 3812.—Forceps No. 18. Molar, Upper. Left Side.

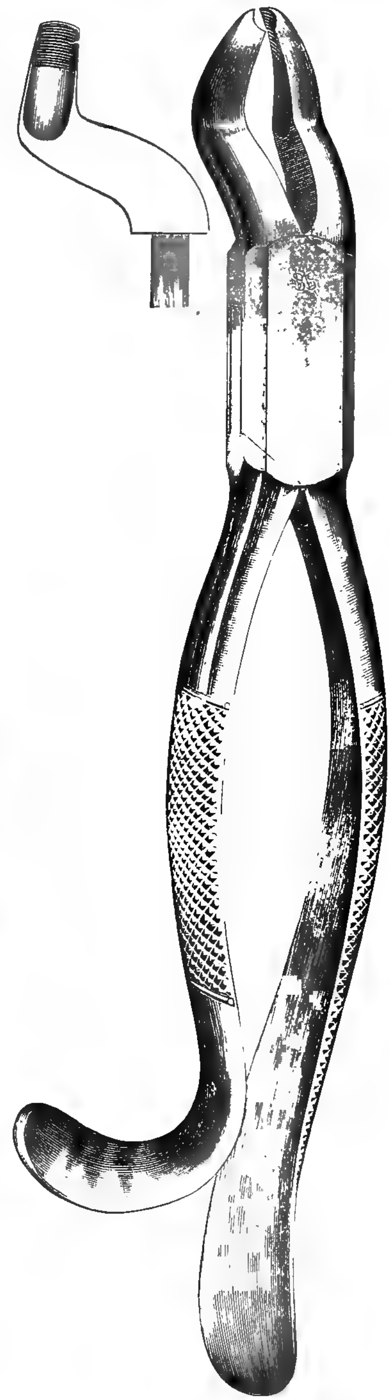

Fig. 3813.—Forceps No. 10. Dentes Sapientiæ, Upper. Either side. Also made with straight handles.

The Process of Extraction.—The process may be divided into three stages:

1. Seizing the tooth with the forceps.
2. Loosening its connection with its surroundings.
3. Removing the tooth from its socket.

moval. To extract the teeth of the upper jaw, the patient should be placed with the head thrown well back, and the operator should stand at the patient's right side. With the left hand the lips and cheeks should be retracted and the upper jaw firmly grasped.

The upper central incisors are extracted with forceps No. 13. Its beaks are made to adapt themselves to the nearly conical neck of this tooth. This forceps should be applied with one beak at the labial surface of the neck of the tooth, and the other at the lingual surface. The beaks of the forceps should be carried well up between the margin of the gum and the root of the tooth. When the tooth has been thus grasped, it should be gently but firmly rotated, in order to loosen it from its socket. A forward-and-back motion may with advantage be combined with the rotatory motion. When the tooth is felt to have been loosened, it should be removed by a steady pull in the direction of its long axis.

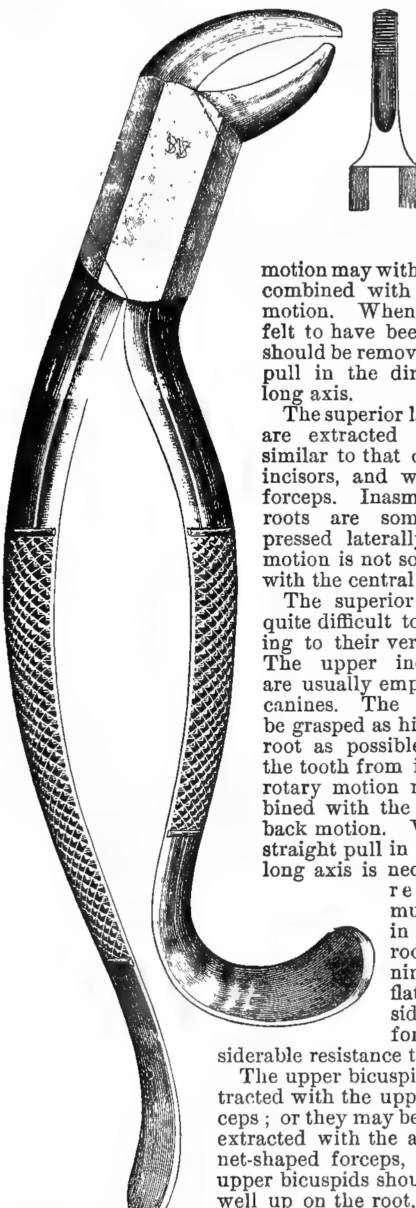

FIG. 3814.—Forceps No. 9. Incisor, Lower. Hawk-bill.

The superior lateral incisors are extracted in a manner similar to that of the central incisors, and with the same forceps. Inasmuch as their roots are somewhat compressed laterally, the rotary motion is not so important as with the central incisors.

The superior canines are quite difficult to extract, owing to their very long roots. The upper incisor forceps are usually employed for the canines. The tooth should be grasped as high up on the root as possible. To loosen the tooth from its socket the rotary motion must be combined with the forward-and-back motion. When loose, a straight pull in the line of its long axis is necessary for its removal. It must be borne in mind that the root of the canine is decidedly flattened on its sides, and therefore offers considerable resistance to rotation.

The upper bicuspids may be extracted with the upper incisor forceps; or they may be conveniently extracted with the alveolar bayonet-shaped forceps, No. 32. The upper bicuspids should be grasped well up on the root, and loosened by a side-to-side motion. Their roots being long and slender, great care is required to prevent their fracture. If the first upper bicuspid has a bifurcated root, it is often impossible to remove the tooth without breaking off the tip of one of the roots.

The first and second upper molars are extracted by forceps No. 18; one pair being suited for the right side and the other for the left. It will be noticed that the inner beak of each forceps is fashioned with a single concavity, it is thus fitted to embrace the inner buccal root of the first or second upper molar. The outer beak is divided by a longitudinal ridge into two concavities, while the tip of the beak is pointed in the middle. It is so made in order to embrace the two buccal roots of the first and second upper molars, and to conform to the depression between these roots. These forceps should be grasped in the palm of the hand, the thumb being brought into position between the angle formed by the two handles and the joint. The third and fourth fingers should be closed over the curve of the left handle. Owing to the divergence of the three roots of the upper first and second molars, considerable loosening is necessary before they can be extracted. This is effected by a side-to-side motion; as the outer alveolar plate is thinner than the inner, the main force should be applied in an outward direction. When the tooth is thoroughly loose in its socket, it can be removed by a downward and outward motion.

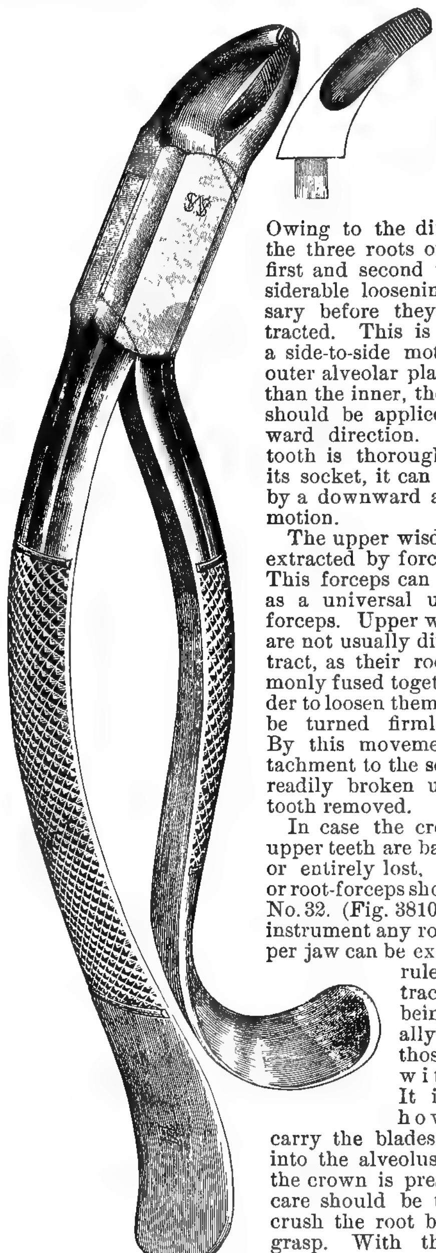

FIG. 3815.—Forceps No. 14. Incisor, Canine, or Bicuspid, Lower. For either side.

The upper wisdom tooth is extracted by forceps No. 10. This forceps can also be used as a universal upper molar forceps. Upper wisdom teeth are not usually difficult to extract, as their roots are commonly fused together. In order to loosen them they should be turned firmly outward. By this movement their attachment to the socket can be readily broken up, and the tooth removed.

In case the crowns of the upper teeth are badly decayed or entirely lost, the alveolar or root-forceps should be used, No. 32. (Fig. 3810.) With this instrument any root of the upper jaw can be extracted; the rules for the extraction of roots being substantially the same as those for teeth with crowns. It is necessary, however, to carry the blades farther up into the alveolus than when the crown is present. Great care should be taken not to crush the root by too firm a grasp. With the first and second upper molars it often happens that the three roots must be extracted separately.

In extracting the inferior teeth the patient should be situated much lower down than for extracting the superior teeth. The operator should stand at the patient's right side; oftentimes well to the back. The lower jaw should be grasped by the left hand, and supported from beneath by the palm and last three fingers, while the thumb and forefinger are placed within the mouth to retract the lips and tongue.

from the tooth to be operated on. The lower incisors are conveniently extracted by forceps No. 9. This may also be used for the right lower canine, and right lower bicuspids. The lower incisors, owing to the lateral compression of their roots, cannot be rotated in the process of loosening them. This must be accomplished by a forward-and-back movement.

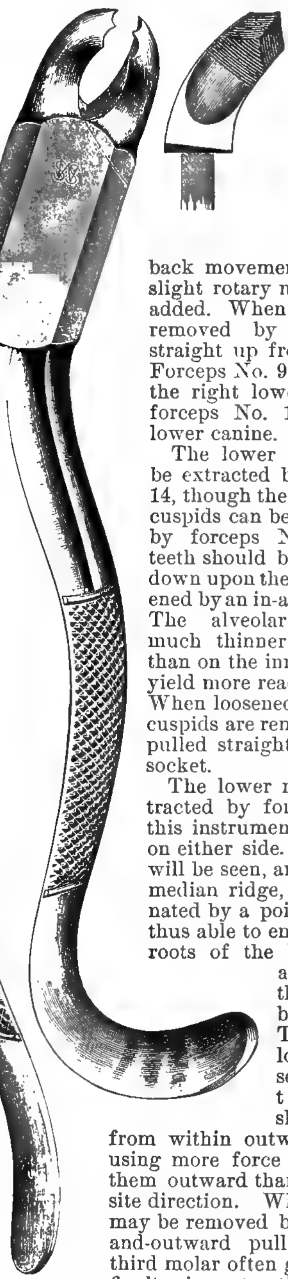

Fig. 3816.—Forceps No. 15. Molar, Lower. Either side.

The lower canines, owing to their very long roots, are often quite difficult to extract. They are to be loosened by a forward-and-back movement, to which a slight rotary motion may be added. When loose, they are removed by being pulled straight up from the socket. Forceps No. 9 are adapted to the right lower canine, and forceps No. 14 to the left lower canine.

The lower bicuspids may be extracted by forceps No. 14, though the right lower bicuspids can be well managed by forceps No. 9. These teeth should be grasped well down upon the root, and loosened by an in-and-out motion. The alveolar plate being much thinner on the outer than on the inner side, it will yield more readily outwards. When loosened, the lower bicuspids are removed by being pulled straight up from the socket.

The lower molars are extracted by forceps No. 15; this instrument can be used on either side. Its beaks, as will be seen, are divided by a median ridge, and are terminated by a pointed tip; it is thus able to embrace the two roots of the lower molars, and to engage the depression between them. To extract the lower first and second molar teeth, they should be rocked from within outward till loose, using more force when turning them outward than in the opposite direction. When loose, they may be removed by an upward-and-outward pull. The lower third molar often gives great difficulty in extraction, owing to the curve of its roots, which hook backward toward the ramus of the jaw. The forceps No. 15 may be used for this tooth. It must be loosened by a side-to-side rocking. Owing to the backward curve of its roots it cannot be lifted from its socket by a force exerted directly upward. In many cases forceps No. 98 is the best instrument with which to dislodge a lower wisdom tooth. It is applicable when the second molar is present. The blades of the forceps are closed between the second and third molars; by depressing the handles the third molar can be pried out of its socket, the second molar being used as a fulcrum. Care should be taken with this instrument that it does not slip and injure the back part of the mouth, and that the dislodged tooth does not fall into the pharynx. Injury to the second molar should likewise be guarded against, since this tooth might be loosened or dislodged in the extraction of the third molar.

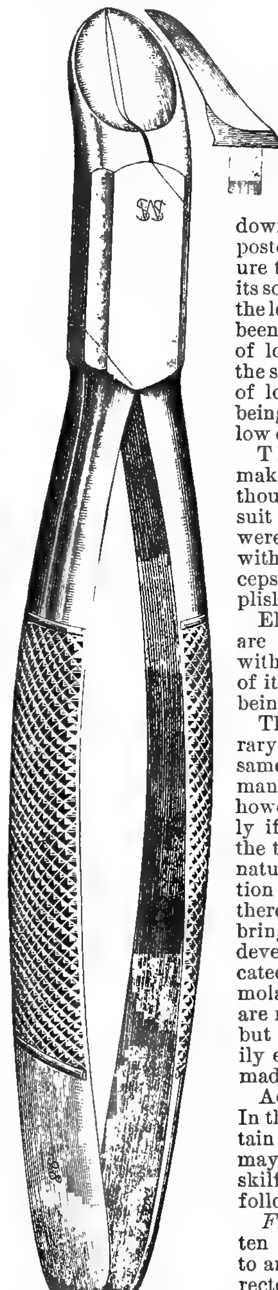

Fig. 3817.—Forceps No. 98. Dentes Sapientiæ, Lower. Either side.

Forceps No. 16 ("the cow-horn") can be used with advantage on the first and second lower molars. The beaks are shaped so as to follow down between the anterior and posterior roots, and by their closure to pry the tooth upward from its socket. To extract the roots of the lower jaw, forceps No. 52 have been designed. The extraction of lower roots is conducted after the same manner as the extraction of lower teeth with crowns, care being taken to apply the forceps as low down on the root as possible.

The instruments described make a good working set, although others might be added to suit individual peculiarities. If it were desirable to extract teeth with the fewest number of forceps, this result could be accomplished with Nos. 10, 15, 32, 52.

Elevators are often useful; they are straight and curved levers, with which a tooth is pried out of its socket, a neighboring tooth being used as a fulcrum.

The extraction of the temporary teeth is performed after the same manner as that of the permanent teeth. The operation is, however, much simpler, especially if performed at a time when the teeth are about to be shed by nature. In the premature extraction of the temporary molars there is always the possibility of bringing away the crown of the developing bicuspid, which is located between the roots of the molar tooth. Diminutive forceps are made for the temporary teeth, but temporary teeth can be readily extracted by the root-forceps made for the permanent teeth.

Accidents of Extraction.—In the extraction of the teeth certain accidents may occur; they may be unavoidable or due to unskilfulness or carelessness. The following are the more common:

Fracture of the Tooth.—This often happens, and is due usually to an excess of force, or to misdirected force, or to an insufficient grip upon the tooth. Cases occur, however, where fracture of the tooth is unavoidable; this is especially the case when the roots are misshapen and locked into the jawbone. When the tips of roots are, as the result of fracture, left in the maxillary bones, it is not always wise to remove them. Nature will usually expel them in due time.

Fracture of the Alveolus.—This occurs, to a limited extent, in every tooth extraction, and produces, as a rule,

no troublesome symptoms. By unskilfulness, however, a large portion of the alveolus surrounding a tooth may be crushed or fractured, and necrosis sometimes ensues.

Fracture of the Jaw may result from tooth-extraction. The fracture may be in the upper jaw, or in the body of the lower jaw. It may or may not imply fault on the part of the operator.

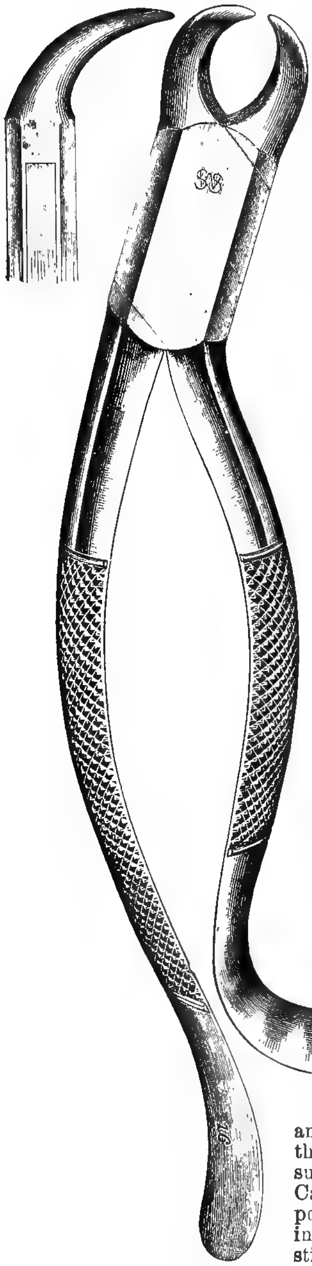

Fig. 3818.—Forceps No. 16. Molar, Lower. Either side. Cow-horn.

Dislocation of the Lower Jaw.—This usually happens with people whose jaws are loosely hung, and are in the habit of slipping out of the socket. If this tendency is known to exist, it is well to apply a roller bandage over the head and under the jaw before operating.

Removal of the Wrong Tooth.—This accident happens, as a rule, only to inexperienced or careless operators.

Removal of Two or more Teeth instead of One.—This may happen from an hypertrophy of the cement uniting adjoining roots below the gum. It may happen when the tooth to be extracted is overlapped by an adjoining tooth. It may happen also by the slipping of an extracting instrument, whereby a loose tooth is knocked out.

Laceration of the Mucous Membrane of the Gum.—This occurs to a limited extent in every extraction, but, through carelessness or unskilfulness, may be very extensive.

Falling of the Tooth into the Œsophagus or Air-passages.—A tooth will sometimes escape from the grasp of the forceps and be swallowed. From this accident no serious results are to be expected. Cases are now and then reported where a tooth falls into the larynx. This constitutes the most serious accident that can attend extraction. Such a tooth may be coughed up from the larynx, or it may enter the bronchial tubes, causing symptoms which are always serious and often fatal.

The inferior dental nerve has been crushed in the extraction of the lower wisdom teeth. In such cases a loss of sensation has occurred in the lower part of the face. Usually this passes away, though it may be permanent. In attempting to extract the roots of the upper bicuspids and molars they have been pushed into the antrum. When this happens the opening into the antrum should be enlarged and the roots removed.

Hæmorrhage after Extraction.—This is usually moderate in amount and of short duration. Such cases require no treatment. There are cases, however, where the hæmorrhage is so prolonged as to produce alarming symptoms, and in rare instances death has resulted. Great care should be taken in dealing with people having the hæmorrhagic diathesis. To control hæmorrhage after extraction the most successful method is to apply pressure to the bleeding parts. The bleeding usually takes place from the socket of the extracted tooth. The socket should be packed with cotton, lint, sponge, or any soft unirritating material. After packing the socket a compress of soft material, covering the socket and surrounding parts should be superadded. Upon this compress a gentle pressure should be maintained, either by the fingers or by the opposing jaw. An effective method of applying pressure after the socket has once been plugged is to soften a piece of gutta-percha in hot water and mould it to the affected region. Enough gutta-percha should be used so that the opposing teeth or alveolus can be embedded in it by the closing of the jaws. Let the jaws be closed and a roller bandage passed over the head and under the chin, and firm and constant pressure is secured upon the bleeding area.

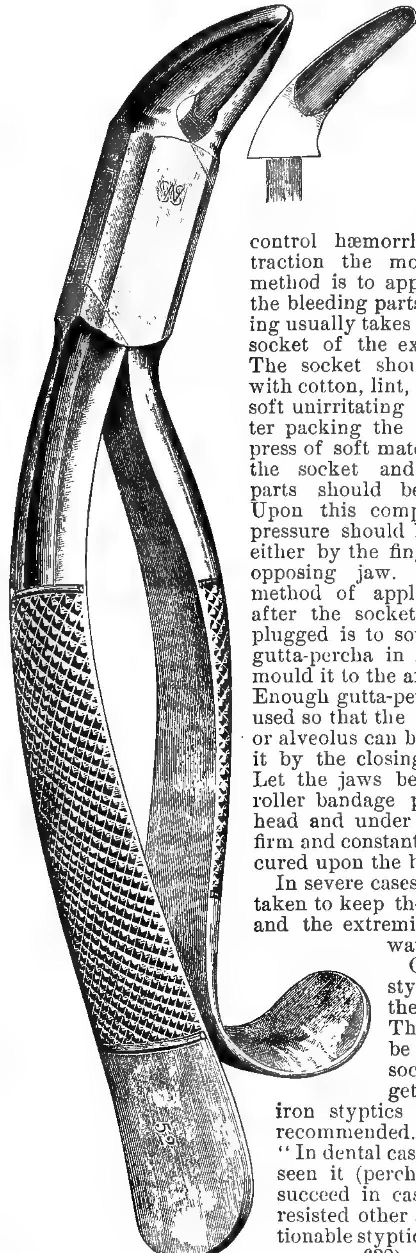

Fig. 3819.—Forceps No. 52. Alveolar, Lower. Either side.

In severe cases care should be taken to keep the head upright and the extremities artificially warmed.

Of the various styptics tannin is the most valuable. The powder may be applied to the socket on a pledget of cotton. The iron styptics are not to be recommended. Tomes says: "In dental cases I have never seen it (perchloride of iron) succeed in cases which had resisted other and less objectionable styptics" (Dental Surgery, p. 632). Tomes relies largely on the use of the matico leaf, softened in warm water and introduced into the socket as a plug, this plug being, if necessary, supplemented by a compress of cotton or lint. Very severe cases of hæmorrhage have been controlled by the use of the actual cautery. If this be used it should not touch the parts, but be held just near enough to bake them. If the cautery touches the tissues a fresh laceration is made by its removal.

In desperate cases of hæmorrhage internal remedies are

usually resorted to. They consist of tannic acid, gallic acid, and ergot.

General Considerations.—Haste in extracting should be avoided; the hand should never move faster than the eye can follow. The tooth should be under complete observation from the time it is grasped by the forceps till it is out of the mouth. The head of the patient should be firmly fixed, and under the control of the left hand or arm.

While considerable force is necessary to extract a tooth, the force should be so guarded and moderated as not to endanger surrounding parts. No jerks or sudden pulls are allowable.

The forceps should never grasp the crowns of teeth alone, as the crown will usually break off, leaving the root undisturbed, but should engage the tooth at its neck, or a little higher up if possible.

In extracting roots the beaks of the forceps should follow down between the root and its alveolus till a firm hold is obtained.

The cutting through of gum and alveolus with a root-forceps is not a desirable procedure, but is allowable in certain cases.

An excellent substitute for a dental chair is a rocking-chair with medium high back, a pillow thrown over the back forming a good head-rest.

William Henry Potter.

TENDON REFLEX. The tendon reflexes, properly speaking, include only certain muscular phenomena which are produced by the sudden stretching of tendons, as by a sharp blow or series of blows, under certain special conditions. Under the name of "deep reflexes," however, we find included with the so-called tendon reflexes proper a number of similar phenomena, which are produced by sharp blows or taps on the fasciæ, the ligaments, or the bones. As these phenomena are, so far as known, in nearly all respects similar to those produced by striking the tendons, all general statements made here may be considered to refer to them also.

When a sharp blow is struck upon the ligamentum patellæ in a healthy person, if the muscles be in a proper state of tension, it is immediately followed by a sudden rapid contraction of the quadriceps extensor femoris, causing the leg to be extended sharply upon the thigh, though only momentarily, as, the contraction ceasing, it immediately resumes its previous position. This is a typical "tendon reflex," which term is used to denote the sudden, rapid contraction produced in a muscle by a sharp blow delivered upon its tendon. As a general rule, in the normal physical condition, only the muscle whose tendon is directly irritated contracts, but in certain hypersensitive states this contraction may involve the neighboring muscles, and even be transmitted mechanically to the corresponding ones on the opposite side of the body. Under ordinary circumstances the "reflex" consists only in a single contraction of the muscle excited, but under certain abnormal conditions the stimulation may be followed by a series of contractions, constituting what is known as a clonus. The most common form of this is the ankle clonus (foot phenomenon), caused by the rapidly alternating contraction and relaxation of the calf muscles; and this will be considered more in detail later.

In healthy individuals only three "tendon reflexes" are found present with considerable constancy, the patellar reflex, that of the Achilles tendon, and the triceps reflex; though the presence of certain other reflexes (radial, ulnar, etc.) is not infrequent and cannot be considered abnormal. Of these the "patellar reflex" is so invariably present in health that its absence, except in old age, is always to be considered as a significant symptom; the triceps reflex and that of the Achilles tendon are very frequently present, but their absence in an otherwise healthy person cannot be held to have any special importance.

The patellar reflex is so far the most important of the "tendon reflexes," both from its value in diagnosis and because of the numerous experiments and investigations which have been made in regard to it, that it may properly be considered as the type of the tendon reflexes.

For this reason we will first describe it thoroughly, and will afterward pass on to the other "tendon reflexes," and point out any special peculiarities or differences which may be found in them.

PATELLAR REFLEX.—*Synonyms:* Patellar tendon reflex, Patellar tendon phenomenon, Knee reflex, Knee-phenomenon, Westphal's symptom, Knee-kick, Knee-jerk, Réflex erotulien, Phénomène du genou, Patellarsehnenreflex (Erb), Kniephänomen (Westphal).

Of these terms we prefer that of knee-jerk, as it implies no theory of cause and describes the phenomenon concisely, and we shall use it hereafter in this article instead of patellar reflex.

In order to obtain the knee-jerk, all that is required under ordinary circumstances is that the patellar tendon should be in a moderate degree of tension. To accomplish this most conveniently, the usual method is that the patient, sitting on a chair, should cross one knee over the other, letting the upper leg hang loosely without support at an angle of about sixty degrees. Or the patient may sit on the edge of a table or a bed, or, if a child, on a chair, letting both legs hang down without support. Commonly one of these methods is the readiest, but if the patient be stout, or for any other reason the knees cannot be readily crossed, it is advisable for the observer to support the limb to be tested on his arm, which is passed beneath it, while his hand rests on the patient's other thigh. When the patient is in bed, the condition of the knee-jerk can either be examined while the patient lies upon his side with the leg flexed at the above-mentioned angle on the thigh, or the thigh can be raised and supported, the leg being allowed to hang at the proper angle. In any of these cases it is well, when possible, if there be any question in regard to the presence of the knee-jerk, that one hand should be placed on the quadriceps extensor cruris, so as to feel the muscular contraction if it occur. Whatever position is adopted, it is important, in order to obtain a good knee-jerk, that the leg should not be held firmly in its position by the patient, either voluntarily or involuntarily, but that the muscles should be so far as possible relaxed, and the leg permitted to hang loosely. After the limb has been properly placed and the situation of the tendon patellæ determined, a sharp blow should be given about the middle of the tendon. The tips of the fingers, or, better, the inner edge of the hand, or in doubtful cases a percussion-hammer, may be used. Ordinarily the knee-jerk is obtained without difficulty through the clothes, unless very thick, but in questionable cases the blow should be delivered on the bare skin.

In this way, in the normal individual, the knee-jerk can usually be readily obtained. In some cases, however, even in otherwise healthy persons, a certain amount of difficulty is found, and in them Jendrássik's method of re-enforcement is useful. Some observers also have found that the knee-jerk is obtained more easily in certain persons by striking the tendon rather toward the inner edge.

History.—The attention of the medical profession was first called to the existence of this phenomenon and that of the ankle clonus, by Erb and Westphal, simultaneously, in articles published in the *Archiv für Psychiatrie*, in 1875, and from that moment these phenomena, especially the knee-jerk, became the subject of numerous scientific researches and investigations. Naturally, at first the diagnostic value of these symptoms received the most careful attention, and the importance of the absence of the knee-jerk in the recognition of tabes dorsalis, especially in the earlier stages, and of its condition as a means of differentiating various forms of disease of the nervous system, caused it at once to obtain recognition, and become the object of earnest study on the part of all the more advanced medical practitioners.

Physiology.—At the same time that its high value as a means of diagnosis and differentiation to the practising physician and surgeon was being practically recognized, its cause and the method of its production attracted interest, and became an object of inquiry to many of the most skilful investigators. This question was found not

to be by any means so simple as it might at first sight appear, and, indeed, up to the present time, the exact mechanism of the knee-jerk is undetermined.

From the very moment when it was first brought to the attention of the medical profession, the mechanism of this phenomenon became the subject of two contrary views, each supported by high authority, and with more or less unanswerable arguments in its favor. The difference between the opinions in regard to its origin held by its two discoverers is apparent even in the terms employed to designate the symptom. On the one hand, Erb, viewing it as the result of a simple reflex process, naturally gave it the name of tendon reflex, and as other tendons were found to act in a similar manner, this symptom became known as the patellar tendon reflex. Westphal, on the other hand, doubted from the very earliest whether this symptom was actually due to ordinary, simple, uncomplicated reflex action, and for this reason refused to accept the designation of tendon reflex until the exact nature of the occurrence could be better known, calling it meanwhile by the more general name of knee-phenomenon, which term has now given way, to a large extent, before the less cumbrous one of knee-jerk.

Immediately on the appearance of the articles of Erb and Westphal, investigations were begun to settle, if possible, the correctness of the opposing theories, and to determine the exact cause and method of production of the phenomenon. In the beginning the general tendency of medical opinion was undoubtedly in favor of the view that the "patellar phenomenon" was due to a simple reflex; even Gowers, afterward a strong opponent of this theory, writing in 1879, says, "the reasons for regarding it as a spinal reflex are strong." That this should be so was only natural, since it was in the first place, superficially, the most obvious and reasonable explanation, and, moreover, it was shown that any obstruction or defect in the reflex is followed by an immediate diminution or loss of the knee-jerk. *The integrity of the reflex arc is necessary to the production of the knee-jerk* (Tschirjiev and others).

Its external similarity, in many respects, to the ordinary reflexes was immediately apparent, and induced many to place it in this class until reasons to the contrary should be shown. These arguments naturally have much weight, and the upholders of the simple reflex theory have sought to strengthen them by others, such as the fact of the radiation of the knee-jerk to the muscles of the back, and the production of a contraction of the quadriceps extensor in the other leg at times.

On the other hand, Westphal and others have raised some very serious objections to this view, and in addition they have advocated another theory. Their argument is as follows: Although the fact be undisputed that the integrity of the reflex arc is necessary to the production of the knee-jerk, still it does not follow that the knee-jerk must in consequence be a simple reflex. On the contrary, that it is not so is shown by the fact that the latent period of the knee-jerk—that is, the time which elapses between the moment of the blow and that of the subsequent muscular contraction—is much shorter than that of any known reflex, and more resembles in this respect the result of direct muscular excitation. It is now generally admitted that the latent period of the knee-jerk is usually from 0.02 to 0.03 second, while that of an ordinary reflex, *e.g.*, skin-reflex, is much greater, 0.12 to 0.14 second. Eulenburg gives the average of his experiments in adults as 0.03226 second. In children it may rise as high as 0.04389 (De Watteville). In this relation Eulenburg's comparative tracings of skin-reflexes and knee-jerks are of much interest.

In regard to the radiation of the knee-jerk to the muscles of the back, and to the quadriceps extensor cruris of the opposite leg, this has been conclusively proved, by the experiments of Prévost and Haller, to be due to the direct vibration conveyed through the bones of the pelvis, inasmuch as it still exists after section of the spinal cord and of the posterior nerve-roots.

The theory of those who are opposed to the simple reflex view is that the knee-jerk is dependent upon the tonicity of the muscle. They say that under normal circumstances a certain amount of tonicity in the muscle—a muscle tonus—always exists; that this, however, is destroyed by injury or destruction of the reflex arc, and that it is due to the loss of muscle tonus that we are unable to obtain the knee-jerk in such cases. Westphal considers three conditions necessary for the knee phenomenon: (1) Tonicity of the muscle; (2) tension of the muscle; (3) elasticity of the ligament. If either of these is lessened beyond a certain point, the knee-jerk is likewise lessened or abolished.

The strongest and most valid objection to this theory is that it presupposes the existence of a muscle tonus. Until we have some definite evidence in favor of its existence, it seems scarcely justifiable first to assume it and then to base a theory upon this assumption.

Pathology.—The pathology of the knee-jerk may be briefly stated. Anything which interrupts the reflex circuit will prevent the appearance of the knee-jerk. The reflex arc for the knee-jerk, beginning in the sensory fibres running in the anterior crural nerve, passes through the posterior nerve-root into the spinal cord between the second and third lumbar vertebræ, and thence returns to the quadriceps extensor femoris through the motor fibres of the anterior crural. In 1877, Schultze and Fürbringen showed that after section of the crural nerve percussion of the patellar tendon was unable to produce contraction of the extensor femoris, although this muscle responded to direct excitations. It is well known that section of the lumbar posterior nerve-roots produces the same result. In the spinal cord, in man at least, the circuit probably passes through the posterior columns. At any rate, it is certain that the knee-jerk disappears, as a rule, in diseases of the posterior columns, while it is increased in lateral sclerosis. At the present time clinical evidence favors the view that it is especially disease or injury of the portion of the posterior columns lying on the border of the lateral columns that causes the abolition of the knee-jerk.

Clinical Value and Symptomatology.—The value of the condition of the knee-jerk as a means of diagnosis has been much disputed, but there is now no longer any question that it is of great importance when its signification is properly understood. In certain cases even, the probability of the existence of certain conditions of the spinal cord can be determined by the character of the knee-jerk alone.

The knee-jerk may be exaggerated, or it may be diminished or absent.

Exaggeration of the Knee-jerk.—The knee-jerk may be rendered more active physiologically in many ways. It has been shown by Jendrássik, Weir Mitchell, and others that when the knee-jerk coincides in time with some other action of the body, or even with certain sensations or emotions, its action is increased; it is *reinforced.* This reinforcement is produced constantly by numerous slight conditions, so that in the healthy normal person the knee-jerk is constantly varying slightly. Thus, Lombard says: "The extent of the normal knee-jerk is continually undergoing change. The average knee-jerk varies in amount at different times of day, being as a rule greatest in the morning, soon after breakfast, and being very much less at night." The decline during the day is irregular, the knee-jerk increasing after each meal. In this case the knee-jerk may be considered as being strengthened by the general physical condition; but it is also momentarily reinforced by any simultaneous action, as motion of the arm, crying, laughing, speaking, or by the sensation of a loud sound. In certain cases this effect is mechanical, due to tension of the muscle. Jendrássik first turned this fact to a practical use by suggesting that in cases where the knee-jerk was diminished, or apparently absent, the patient should be told to clinch his hands and pull on them as strongly as possible, and that while he was thus engaged the knee-jerk should be tested. This procedure acts to increase the knee-jerk in two ways: first, probably as actual reinforcement; secondly, by distracting the patient's attention and preventing him from keeping his limb in that condition of tension which hinders or prevents its movement. As a general

rule we may consider that the stronger the reinforcement is, the more marked will be the knee-jerk.

The knee-jerk is also increased by certain bodily conditions. It is increased by chronic fatigue, and in almost all cases of weakness and irritability of the nervous system, from whatever cause. Thus, we find it exaggerated in nearly all cases of neurasthenia, of spinal irritation, of hysteria—in fact, in all forms of functional nervous disorder where irritation or irritability may be presumed to exist. It is found increased in all cases of general weakness of the nervous system—nervousness—to a greater or less extent, and hence appears frequently—in fact, as a rule—to be so in persons convalescent from severe disease, and in many cases of chronic disease, phthisis, etc.

It is also pathologically increased in certain irritative or inflammatory lesions of the central nervous system. It is thus exaggerated in certain stages of cerebral meningitis and in spinal meningitis. But the most highly developed pathological forms of knee-jerk (knee-clonus, knee-tetanus) are found principally in certain definite lesions of the spinal cord. In lateral sclerosis the knee-jerk is almost typical in its exaggeration, and, *vice versa*, when the knee-jerk is increased beyond a certain point it strongly suggests the presence of disease of the lateral columns. In no other disease does it reach the extent which it does in this, or is it capable of being so easily excited.

Increase in the knee-jerk occurs in all cases whenever the access of voluntary innervation to the muscles is hindered, however slightly.

It is especially increased in cases of transverse myelitis when this occurs in the dorsal or cervical regions, while the same affection in the lumbar region abolishes it.

It accompanies not only central organic lesions, but also hysterical. It is found even with lesions of the pyramidal tracts which produce no perceptible paralysis.

The knee-jerk is likewise increased by causes which increase the general irritability of the spinal cord. Thus, we find it exaggerated in tetanus and in poisoning by strychnia.

It should, moreover, theoretically, be capable of increase through pathological conditions of the muscle, tendon, etc., but in regard to this we have as yet no definite knowledge.

Diminution of the Knee-jerk.—In the normal, healthy individual the knee-jerk is, in a certain number of cases, only to be obtained with care and difficulty, and is decidedly below the average. This seems to be idiopathic or constitutional. Whether this can absolutely reach the point of absence without the existence of any disease or disturbance in the nerves or spinal cord, while the proper conditions exist in the muscles and tendon, seems doubtful. For practical purposes, however, we may admit the existence of a small number of such cases, but they are so rare, that the value of the absence of the knee-jerk as a diagnostic symptom is not thereby essentially lessened. Physiologically, the knee-jerk is diminished by conditions of temporary fatigue. It is sometimes difficult to obtain it in infants and children, and it is said to be often absent in old age.

Pathologically, absence of the knee-jerk may be caused by anything which breaks or interrupts the current of the reflex arc. It may even be produced by causes which give rise to no appreciable organic lesion, as stretching of the anterior crural nerve. It is caused frequently by neuritis of the anterior crural or its branches, and this is probably the cause of its absence in certain cases after diphtheria, in diabetes, in phthisis, and after typhoid fever and other acute diseases. For this reason it is apt to be absent in multiple neuritis of whatever origin, whether idiopathic, syphilitic, toxic (due to alcohol, lead, or arsenic), or accompanying general paralysis. It may also, of course, be produced by injuries, especially section of the anterior crural. Likewise, it may be caused by anything which prevents the transmission of impulses through either the anterior or posterior nerve-roots (injuries, tumors, etc.). As previously stated, the path which the sensory impulse takes in the spinal cord after leaving the posterior nerve-roots is not yet wholly settled, but it seems to be especially connected with the external portions of the posterior columns. At any rate, disease or destruction of the posterior columns of the spinal cord in the lumbar region produces absence of the knee-jerk. This is one cause of its absence in tabes dorsalis—sclerosis of the posterior columns—a disease in which the absence of the knee-jerk has become a most important diagnostic symptom and is sometimes an early one. But the knee-jerk may also be abolished by any other cause equally affecting the posterior columns, even though it do not present the clinical picture of tabes. Thus, it may be absent in transverse myelitis in the lumbar region of the cord (always is, if the myelitis be complete), in certain forms of diffused myelitis, in disseminated sclerosis, and in tumors or other growths affecting the spinal cord. Injuries and sections of the cord in this region, respectively, may and must abolish it. But the posterior columns are not the only part of the cord the affection of which seems to produce abolition of the knee-jerk. It is also absent in almost all cases of anterior poliomyelitis. In *infantile paralysis*, indeed, the diagnosis is always rendered doubtful until after long examination, if the knee-jerk be present.

Whenever the knee-jerk is totally absent for a considerable period without other symptoms, it points toward disease of the posterior columns.

The knee-jerk may likewise be diminished or abolished by cerebral influences. This is the case in opium narcosis, and in all forms of coma.

It may also be diminished or caused to disappear entirely from purely mechanical causes. The tension of the quadriceps extensor femoris may be rendered so great that it is unable to contract readily. This may occur from the too great flexion of the leg on the thigh, or from some pathological condition in the muscle. Again, the tendon or the muscle may be so relaxed that no reaction can be obtained by tapping the tendon, as occurs when the leg is fully extended on the thigh. Lastly, it is said that in cases where a mass of fat is situated directly beneath the tendon this prevents its vibration, and in such case no knee-jerk can be obtained (Westphal).

Ankle Clonus.—Next to the knee-jerk, by far the most important of the deep reflexes, from a diagnostic point of view, is that caused by the stretching of the Achilles tendon, and usually known as the Achilles tendon reaction, or in the more advanced stage as the ankle clonus (foot-phenomenon of Westphal). Like the knee-jerk, it was first brought to the notice of the medical profession by Westphal, and Erb, simultaneously, in 1875, and since then has been the object of much study. The Achilles tendon reaction is almost always present in the healthy individual, and may be developed by tapping the Achilles tendon sharply with the fingers or a percussion hammer while it is in a state of tension. In consists in a single contraction of the external muscles of the calf (gastrocnemius and soleus), and is to be carefully distinguished from the ankle clonus, which is a series of rhythmical contractions of the same muscles, and bears the same relation to it that the knee-clonus does to the knee-jerk.

The ankle clonus is produced usually by the sudden and forced flexion (dorsal flexion) of the foot upon the leg, which causes the stretching of the Achilles tendon, and it consists in rhythmical contractions of the calf muscles, which cause involuntary extension of the foot. In severe cases these contractions may be developed to a high degree, and in most cases where ankle clonus exists the contractions will continue so long as the tendon is kept tense. As a rule, with the exception of one or two weak contractions, the clonus ceases immediately on the cessation of the forced tension of the tendon, but the contractions can be made to cease instantly by extending the foot and thus relaxing the tendon. Ankle clonus does not occur in the healthy individual under ordinary circumstances, but it may be produced if desired. If, for example, anyone while sitting, the leg being at an acute angle with the thigh, will let the foot rest upon the ball of the toe, the heel being raised and unsupported, and

will then voluntarily raise and lower the heel, "imitating the movements made when an infant is dandled on the knee," he will soon find that the movements are continued involuntarily, and cannot be stopped without a distinct effort. The ordinary method, however, of testing for ankle clonus is for the physician to grasp the foot firmly with one hand, while the patient's leg is almost fully extended upon the thigh, and to suddenly and forcibly flex the foot dorsally upon the leg. Tension of the Achilles tendon is thus best produced.

The contractions of the muscles in ankle clonus are, as before stated, rhythmical, and, according to Gowers, occur at the rate of from six to ten per second.

An exaggeration of the tendo Achillis reaction may be obtained under the same conditions as exaggeration of the other deep reflexes. The foot clonus may be obtained in slight chloroform narcosis, but not under ether or nitrous oxide. It is also present for a short time after certain epileptic attacks. A slight clonus also occurs at times in cases of great functional nervous irritability, toxic or other (tobacco, alcohol), but this is usually temporary. Gowers believes that, when "a uniform clonus can be obtained by simple flexion of the foot," it "is always pathological, always indicates grave nutritive changes in the spinal cord, and that there is, in most cases in which it can be obtained, actual degeneration in the fibres of the lateral columns."

The diagnostic value of the ankle clonus consists in the fact that it is only present when the deep reflexes are much exaggerated, and may be regarded usually as a sign of some affection or lesion of the corresponding lateral column of the spinal cord. It occurs in its most typical form in sclerosis of the lateral columns, and it is often present on the affected side in cases of cerebral hemiplegia, in which case we are justified in presuming that an affection of these columns exists. It naturally occurs also in cases of transverse myelitis, and in tumors of the cord or its membranes where these columns are affected. It is even present in amyotrophic lateral sclerosis, where both the lateral and the posterior columns are involved.

It is scarcely necessary to state that the spurious or voluntary foot clonus, which sometimes is found in hysteria, should be carefully distinguished. This latter is produced by the voluntary contraction of the calf muscles as the patient pushes the foot against the physician's hand, and does not, like the true clonus, begin immediately on the forced extension of the tendon, but some seconds after.

Other Deep Reflexes.—With the exception of the knee-jerk and the Achilles tendon reaction, the so-called deep reflexes of the upper extremity, the triceps, the ulnar, and the radial, of which the last two are periosteal, are the only ones which occur in any large proportion of healthy persons, and these have no special clinical significance. Many other deep reflexes, however, occur under abnormal or pathological conditions. Under the same circumstances which produce exaggeration of the knee-jerk or of the Achilles tendon reaction, muscular contractions from the tension of other tendons begin to appear in the corresponding muscles, and various similar phenomena from the tapping of the periosteum or fascia in various parts of the body. Thus, as regards those produced from tendons, reactions may be obtained from those of the biceps, the supinator longus, the radial extensors, the flexors of the fingers, etc., in the upper extremities; and from those of the adductors of the thigh, the gracilis, the biceps femoris, the tibialis anticus, the tibialis posticus, and the peroneus longus in the lower extremities.

Of the periosteal reflexes the best known is the "front tap," or "tibial tap," which terms are used to denote the sudden contraction of the quadriceps femoris produced by a gentle blow on the front of the tibia, near its middle. This usually exists under the same conditions as the ankle clonus. The ulnar and radial reactions mentioned above are obtained by tapping the lower ends of the ulna and radius, which causes respectively contractions of the triceps and biceps. Many other periosteal reflexes may occur, and in some cases even moderately distant muscles may react (remote reflexes), as in the scapular and clavicular reflexes, where, on tapping the spine of the scapula, a contraction is caused in the deltoid, and the biceps reacts to a blow on the sternal end of the clavicle. Contractions of the chest muscles may sometimes be produced by striking the costal cartilages or the ribs, while blows on the transverse processes of the cervical vertebræ may cause contractions of the muscles of the upper arm, and on those of the lumbar vertebræ contractions of the glutei and adductors of the thigh.

When the excitability of the deep reflexes is greatly increased, we even begin to find other forms of clonus, and this is especially common in cases of late hemiplegic rigidity. Thus a wrist clonus may be produced by a sudden and forcible hyperextension of the wrist, or a toe clonus may exist, caused by rhythmical contractions of the abductor and flexor brevis pollicis. Gowers also describes a lateral ankle clonus from contraction of the peronei, which can be produced by passive pressure of the foot inward.

Spinal Epilepsy.—Under this name is known a condition in which the whole lower extremity shakes *en masse*, forcibly and violently, when moved passively, or even when touched. This is considered to be due to an increase in the excitability of the Achilles tendon greater than that which exists in ankle clonus (Möbius), or to "combined contractions due to stimulation of some of the superficial and deep reflexes" (Ross). It only occurs in cases of degeneration of the lateral columns of the cord, and is perhaps most frequently to be observed in paraplegia from Pott's disease, or in other forms of transverse myelitis.

Paradoxical Contraction (Westphal).—This phenomenon may be considered roughly as the opposite of the ordinary tendon reaction. It consists in the contraction of a muscle caused by the passive approximation of its extremities. It is best known in the tibialis anticus, in which it may be produced in the proper cases by the rapid dorsal flexion of the foot. In these cases the foot remains, after the pressure has ceased, firmly fixed in the position of dorsal flexion, and may be held so many minutes. Other muscles sometimes assist the tibialis, as the extensor communis digitorum and the extensor brevis pollicis. This form of contraction has also been observed in the biceps femoris, and may even occur in the muscles of the upper extremity. It is found principally in those muscles of the extremities in which the "tendon reflexes" are rare and difficult to obtain, and, on the other hand, does not seem to occur in those, like the quadriceps femoris, in which they are ordinarily present. Paradoxical contraction is said to be usually associated with paresis of the lower extremities. It occurs when the deep reflexes are absent or normal, and even when they are somewhat exaggerated; but it cannot occur, at least in the tibialis, when an ankle clonus exists. It has not been observed where there is an excess of cutaneous sensibility. This phenomenon is found only in disease. It has been observed in cases of combined sclerosis of the posterior and lateral columns, in paralysis agitans (Westphal), and in hæmatomyelia (Ross).

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TENDONS, DISEASES AND INJURIES OF. The tendons are not so often the seat of surgical disease as are their sheaths, and some consideration of the diseases of the latter must unavoidably be included in a description of the affections of the tendons themselves.

Necrosis of tendons may follow injury or inflammatory conditions of the surrounding tissues, or may be a part of a general necrosis. This is readily understood when one considers that the tendons are organs of rather low vitality, and that their blood-supply is easily cut off. This necrosis may prove very troublesome and exhausting in an already depreciated condition of the system. The story of such a case, which occurred in the practice of Dr. E. M. Culver, of New York, may not prove uninteresting: An old lady, seventy-three years of age, was suffering from senile gangrene involving the great toe. The sphacelus had come away, leaving a clean granulating surface, but in the sole of the foot, opposite the metatarso-phalangal joint, was an abscess. Slight manipulation of this abscess caused a considerable quantity of fetid pus to escape through the ulcer. Incision of the abscess showed that the necrosis of the flexor tendon of the toe had been its exciting cause. The process continued, and several abscesses were opened along the course of the tendon before recovery ensued. Although so extreme a case from this cause is not common, the death of tendons is not rare after contused wounds, and as a sequel of suppuration in the tendon-sheaths. After necrosis has occurred, the tendon is seldom, if ever, reformed, and the function of the part is permanently impaired. The condition is not one which permits of special treatment for the tendons, except prompt evacuation of all collections of pus, and the removal of the necrotic tissue as fast as it separates from the seemingly sound parts.

Tumors do not often involve the tendons, but they may do so. Carcinoma and sarcoma develop in this tissue only through extension by contiguity, and do not form there by metastasis. Occasionally small fibromata develop upon the tendons, and give rise to more or less annoyance. They are usually quite small, and do not often attract much attention unless they interfere with the proper action of the tendon, or are painful by being so situated that they are subject to pressure. These fibromata may be felt as small, hard lumps beneath the skin, adherent to, and moving with, the tendons. The flexors of the fingers are their most usual site. They are, as a rule, neither painful nor tender, nor do they increase rapidly in size, nor incline to become adherent to the surrounding tissues. These fibromata are said to tend to become sarcomata when they are of large size or rapid growth. This tendency should lead one to exercise caution in refusing to operate upon a tumor that seems to be innocuous. Should it become necessary to treat these growths, they may be removed, provided antiseptic precautions are taken, and care is observed that the tendon does not become adherent to the sheath at the part from which the tumor was removed. Gummata may form upon tendons, but their identification is involved in their history and in the recognition of concurrent lesions, as well as in their disappearance after antisyphilitic treatment with mercury and the iodides. For a description of the cystic tumors springing from the tendon-sheaths, see article Ganglion (Vol. III., p. 297).

Acute tenosynovitis (inflammation of the sheath of a tendon, thecitis) may follow strains or wounds, or may complicate syphilis, gonorrhœa, or rheumatism. Occasionally such an attack is seen during the course of one of the continued fevers. The severity of the attack depends, generally speaking, upon the presence or absence of suppuration; the presence of pus rendering the affection much more grave. It will be found convenient to speak of suppurative tenosynovitis separately.

Non-suppurating Tenosynovitis.—In the traumatic cases of acute non-suppurating tenosynovitis, where no wound has occurred, the disease may follow prolonged or repeated muscular efforts; or a single severe strain, as in giving a hard blow with the fist, or a strong push; or it may follow contusion. Dr. G. B. Phelps, of New York, whose experience has been large in this class of cases, informs me that he has observed that tenosynovitis most often attacks those who change from an accustomed to an unaccustomed form of hard labor, and those who have been idle and have just obtained work. He thinks that it comparatively seldom follows a single severe effort. It attacks most often the flexor group in the wrist; though it is also seen in other localities, notably the extensors of the fingers at the wrist, the tendons about the ankle, and the long tendon of the biceps cubiti. The symptoms which point to tenosynovitis are pain and tenderness, with some swelling, along a tendon-sheath. This pain will be increased by active or passive motion of the tendon. The disability of the part is complete on account of the pain; or, rather, motion in the part controlled by the tendon will be avoided and the part will be held in a position most favorable for rest. In addition to this, there may often be felt a peculiar rustling feeling of crepitation, difficult to describe, but which resembles in some degree the sensation produced by subcutaneous emphysema. The sensation may, perhaps, be conceived, if one has a good imagination, by likening it to feeling crepitant râles. This condition is explained by the pathological condition which exists. The changes which occur are those of all serous inflammations: Congestion, followed by serous, and subsequently fibrinous, exudation. These cases usually do well, though occasionally recovery takes place with an adherent tendon. There is but little tendency to become chronic, and the inflammation seldom becomes purulent unless by infection from an open wound.

The duration of the disease is from a week to a month, depending upon the severity of the attack and the constitutional ability of the patient to recover from any inflammatory disorder. Constitutional treatment is not usually demanded in these cases when of traumatic origin. Opium may be needed to relieve the pain, and an occasional laxative may be indicated. Rest, pressure, and counter-irritation are the chief factors in the treatment of acute tenosynovitis. Rest is secured by splints. Pressure evenly applied and extending above and below the site of the lesion is invaluable. This is well obtained by the application of a "cotton dressing," which consists of a tolerably thick layer of cotton-wool firmly bandaged in place. The rubber (Martin's) bandage may be used, if it is well borne, though an ordinary muslin roller bandage is commonly quite sufficient. Counter-irritation in the milder cases, uncomplicated by wounds, is almost always of use. Iodine is a common application for this purpose, and may be used in the form of the officinal tincture, or better, perhaps, in that of the ointment. This is perhaps as good as any of the milder counter-irritants. If the pain is severe the mildly astringent and anodyne lead and opium wash (Lotio Plumbi et Opii, U. S. Ph.) will often serve a good turn, and may be applied hot or iced, as desired, until the pain is nearly or entirely relieved. Hot or cold water applications are often advised under the same circumstances, until a more permanent dressing can be borne. Moderate passive motion may be used if the attack is prolonged and there seems to be a tendency for the tendons to form adhesions. The rheumatic, syphilitic, and gonorrhœal forms of tenosynovitis require treatment directed to the causal disease, in addition to that above described.

Suppurative tenosynovitis usually follows wounds of the tendon-sheaths which have become infected; but may occur after very slight injuries in the neighborhood of the tendon; and, sometimes, it seems to occur after the milder form without open wound. The trouble, once started, resembles cellulitis in its course. It may be entirely local or may involve, in a very short time, a whole member. The disease is characterized by very severe

pain of a throbbing character, by fever and occasional chills, and by marked prostration, in addition to the symptoms already noted as characterizing the milder type. The skin is reddened in these cases, and the local tenderness is more marked than in the non-suppurative cases. The tendency of the disease is toward destruction of more or less of the tissues attacked, and recovery is often rendered incomplete by the presence of unyielding tendons, by unsightly scars, and by the contractions resulting. In some cases even amputation is necessary to save life, so virulent is the septic attack. The treatment is the same as that of suppurating cellulitis, viz., free evacuation of pus and clean after-treatment. As soon as the presence of suppuration in a tendon-sheath seems assured, it is necessary to freely incise the sheath and drain the part as much as may be necessary. The tendons are liable to necrose in these cases, and often considerable deformity may result in this way.

Calcification of Tendons.—Old people who have been subject to rheumatic attacks may have deposits of lime in one or more of the tendons. This occurs near stiffened joints in most instances. The patellar tendon, above or below the bone, is a frequent site for such a condition. These tendons are especially liable to rupture by muscular violence. It is not a condition which admits of active treatment.

Chronic Tenosynovitis (hygroma, compound ganglion) is a disease characterized by gradually increasing, painless swelling, more or less loss of power, and the development of certain small fibrinous masses in the distended tendon-sheath. These masses are known as rice-bodies or melon-seed bodies. The affection may follow the acute form, or may be of gradual development without any apparent cause. The etiology of chronic tenosynovitis is rather obscure; it is often tubercular and sometimes syphilitic or rheumatic in origin, besides, as we have seen, arising from trauma through the acute form. It most commonly affects the flexor tendons in the forearm and hand, in which situation the swelling will be seen above and below the annular ligament, and divided by it into two portions. Pain and tenderness are not often marked in this as in most chronic inflammations. The disability is of gradual development and is not usually complete; the common experience is, that prolonged effort weakens the part so that it incapacitates the patient for his usual work. The tumor is fluctuating, and the wave, started from either pouch of the sheath, may be felt to pass into and distend the other. The rice-bodies may sometimes be felt to interrupt the regular current of the distending wave as they pass through the narrower portion of the sac beneath the annular ligament. The diagnosis is not usually difficult in these cases, though, if there has been spontaneous or operative opening of the cyst, with pouting granulations and serous discharge, the appearance may simulate that of a malignant growth or a carious joint.

Left alone, the disease does not tend to recovery. There are reported many cases of failure to cure, of anchylosis from tendon adhesion, and even some of caries of the carpal bones, and of amputation to save life after operation; but when the operation is performed with antiseptic precautions many cases may recover quickly and permanently. The cure demands treatment by operation. Benefit does not often follow local measures, nor the injection of the cyst. The treatment which is usually the most successful is that of opening the sac above and below the annular ligament, thoroughly washing out the cavity, and clearing it of the rice-bodies. The surfaces may require to be scraped with a sharp spoon, to detach some of the fibrinous fungosities. The entire cavity should then be drained by a tube passed through both openings, the one in the palm and the other in the forearm. A splint is, of course, a necessary part of the dressing. If the splint can be so arranged as to avoid its removal for the subsequent dressings, much pain is avoided during the first few changes. The other methods by which these chronic inflammations have been treated need hardly occupy our time. Evacuation by a cannula and drainage, the splitting of the whole length of the wall (including annular ligament), and setons have all been of use, but do not seem to offer greater advantages than the operation mentioned.

Dislocation may follow severe strains of the tendons. This occurs rarely in any locality, but perhaps most often at the ankle, where the anatomical relation of the tendons to the malleoli is such as to permit the accident. It also occurs as a complication of fractures and of dislocations of the bones. The symptoms are pain, tenderness, and disturbance of function, with, usually, deformity. The diagnosis may be uncertain, unless the deformity caused by the absence of the tendon from its usual site can be detected. This may be obscured by the thickness of the overlying tissues and by swelling after injury. At the ankle, where the injury most often occurs and where the results of dislocation would seem most serious, the displaced tendons may easily be felt. The outlook is not ultimately unfavorable, as the probability of the tendon reassuming its function in its new locality is considerable, even when attempts at retention after reduction fail. Manipulation seldom fails to reduce the displaced tendon, but its retention is often a matter of great difficulty. This may usually, however, be accomplished by pads and snug bandaging, perhaps with an elastic bandage. The part must be immobilized for a considerable time, and its use prohibited until the retaining bands are strongly re-formed. Tenotomy may be necessary to prevent muscular action throwing the tendon out before it has become solid in its bed.

Rupture of Tendons.—This accident occurs with surprising frequency when one considers that the sudden violence of machinery accidents, involving great strain of tendons, is more apt to tear out the tendon entire than to rupture it. This is shown in the case of evulsed fingers, where the separation occurs between the muscle and tendon, and not in the body of the tendon. Sudden muscular action is usually the cause of the accident. As a rule, the tendons that break are the seat of some degenerative lesion, and for this reason the accident is more common in persons past their physical prime. The tendons most often ruptured are the long tendon of the biceps cubiti, the tendon of the quadriceps extensor cruris (above or below the patella), the tendo Achillis, and the tendon of the plantaris muscle. The occurrence of such an accident is denoted by a sudden snap, often both felt and heard by the patient, and by pain and loss of function. A day or two later, ecchymosis under the skin may be present. The defect in the tendon may be felt in the case of a superficial tendon, like the tendo Achillis. A cramp-like bunching of the muscle may also be noted, and may be of service in confirming the diagnosis. The result of the injury is not usually serious, with proper treatment. Union takes place by the organization of the clot which forms, as in subcutaneous tenotomy, and after a time the appearance of the tendon is normal. The treatment after the rupture of tendons is entirely by position and such aid as can be secured by bandaging in such a manner as to relax the contracted muscle. For example, the tendo Achillis being ruptured, the treatment should consist of apposition of the ends as nearly as possible by bandaging the leg firmly from above downward, strong extension of the foot, and fixation in an immovable splint.

Wounds of the Tendons.—The wounds of tendons are of the same nature as are wounds in general. They may be the result of an accident, or may be made by the surgeon. Such wounds may be classified as open or subcutaneous; operative wounds falling, in most cases, in the latter class. The wounds may be further classified as incised, punctured, or contused; as transverse or longitudinal; clean or infected; and complete or partial, according as the entire tendon or a part of it is divided. The usual condition which demands the surgeon's attention is a transverse incised wound, more or less unclean, in which one or more tendons have been divided. Such wounds are perhaps most common in the forearm, about the wrist-joint, and in this location the number of tendons involved may be quite large. To a less degree, the tendons passing the ankle and knee-joints are liable to be cut. Knives,

sharp tools, and glass are the usual instruments with which the wounds are made. After the complete division of a tendon the symptoms are complete loss of function, retraction of the tendon, and more or less "bunching" of the muscle of which the tendon is a part. The loss of function is not complete with partial division. Longitudinal and punctured wounds do not often occasion complete disability or loss of function, unless inflammation in the sheath of the tendon be present. Even after the original wound is healed the detection of the cut tendon is usually easy. The divided end of the tendon will be involved in the cicatrix, which will be drawn by the contraction of the muscle. Sometimes the defect may be felt in the tendon, and occasionally the contracted muscle may be prominent.

A cut tendon, if left to itself, is not likely to heal with restoration of function, for the newly formed part may not entirely fill the gap between the divided ends; and, furthermore, adhesions are likely to take place. Inflammation may in the same way lock the part. Secondary operations are often of use, and if the tendon is a functionally important one, they should be attempted. Contused and infected wounds of tendons, when severe suppuration occurs, are apt to be followed by sloughing of the tendons. Amputation of a small member is sometimes advisable, when permanent stiffening has occurred on account of a tendon-wound, in order to get the part out of the way of a more useful member which may do its work. Subcutaneous injuries and uninfected open wounds almost always unite without loss of function, when the parts can be approximated and retained for a sufficient time to allow union.

In the case of recent wounds, in which tendons have been divided, the question of their immediate suture is to be decided upon general surgical principles. If the wound is clean, or susceptible of being made surgically clean, it will, in most cases, be best to unite the divided ends of the tendon. In granulating wounds the same is usually true. Suppurating wounds will need preparatory treatment to render them aseptic. When the tendon is only partially divided the use of sutures is not commonly demanded, as the divided fibres will usually unite sufficiently without operation. When a number of tendons are divided it is difficult to unite the distal ends to their respective muscles, because of the disturbed anatomical relations and the similarity of one tendon to another. This is especially true at the flexor side of the wrist. This does not seem to be essential, however, as nature seems to permit the muscle to serve in its new duty without destruction of the co-ordinating power. Rest is very essential to a part after these operations, and should be secured by a splint so arranged as not to require removal for the dressings. The splint should be retained until the union is firm—usually for from three to eight weeks. Drainage, too, must be very carefully looked after, for often sutured tendons survive suppuration in the wound when the products of the inflammation are well drained away.

The Suture of Tendons.—In suturing tendons the most accurate details of antisepsis should be followed, because the least suppuration will often mean the undoing of all the work, plus the danger of suppurative inflammation extending in the sheath of the tendon. Complete general anæsthesia is commonly best, as it enables the operator to work at his leisure, and relaxes the muscles of the patient. To bring the retracted tendon into view, the part should be relaxed as much as possible by position. A rubber bandage (Esmarch's), applied from above downward over the muscle, may advance the tendon sufficiently to enable one to draw it into view with forceps. Often it will be found advantageous to enlarge the original wound, both to afford space for working and to facilitate the discovery of the tendon. The tendon may be sutured without special preparation, or the ends may previously be freshened, as seems to be expedient. Bevelling the ends by an oblique section will increase the area of the apposing surfaces. If the wound is to be closed, absorbable sutures should be used for approximation; moderately heavy catgut will often hold long enough to allow union, if the action of the tendon is prevented. If the wound is to be treated openly, silkworm-gut or silk may be used by preference. These sutures, usually two or three in number, are passed at a distance of about a fourth of an inch from the cut ends, and are to be left without tension. Great care must be used not to tear the stitches out by violence, or by using a needle large enough to split the tendon. The flat needle of Hagedorn is especially useful here. Sutures for relaxation should also be inserted at a greater distance, or the tendon may be temporarily held by a hare-lip pin, or by a suture of silver wire passed through the skin at the upper border of the wound. The relaxed position must be carefully maintained after the operation.

In the case of old injuries in which tendons have been divided, much improvement can often be effected by careful suture of the tendon. The cut ends of the tendon should be carefully dissected from the sheath to which they have formed adhesions, and should then be freshened before approximation by stitches. It is sometimes impossible to find the retracted tendon, and under these circumstances it has been found admissible to insert the distal end of the tendon into the body of one having a similar function. For example, the common flexor tendon supplying one finger may be spliced to that controlling another. This splicing is done by making a partial oblique division of the tendon and inserting the freshened end of the cut tendon in the space thus made. It has occasionally been found expedient to divide a less useful tendon and divert its muscle to a new function by uniting it to the stump of another severed tendon having a more important function. *F. A. Manning.*

TENESMUS. Syn.: Fr., Tenesme; Ger., Stuhlzwang; Gr., τεινεσμός, from τείνω, to stretch. By this term is understood a painful straining at stool, accompanied by spasmodic contractions of the sphincter ani muscle. It occurs when the rectum contains little or no fæces, but when the mucous lining of the bowel is in an irritable condition, arousing a sensation as of a large amount of material in the rectum, and causing an urgent desire to defecate; at the same time the irritable state of the mucous membrane covering the sphincter causes that muscle to contract violently. Usually a little mucus, often streaked with blood, with occasionally some fluid fæcal matter, is extruded in the intervals of the spasmodic closure of the sphincter. The straining is wholly involuntary, and is sometimes so severe as to cause prolapse of the bowel. Tenesmus is a symptom of any inflammatory condition of the mucous coat of the rectum or sphincter. It is commonly met with in dysentery, hæmorrhoids, and cancerous disease of the rectum; in intussusception involving the large intestine; in the rare instances of gouty inflammation of the lower bowel; in prolapse of the rectum, and occasionally in fistula or fissure of the anus.

As tenesmus is merely a symptom, the treatment should, of course, be directed to the cure of the causal disease. But the symptom is at times so distressing, that it demands treatment for itself, apart from that of the primary affection. A considerable measure of relief may often be afforded by small starch enemata to which a little laudanum has been added. Suppositories of opium and belladonna are also useful. Trousseau speaks highly of injections of a decoction of rhatany, of the strength of ʒ j. to the pint, after each stool. Very minute doses of gamboge have been recommended. Occasionally, ice suppositories or small enemata of cold water will serve a useful purpose, and at other times more relief may be afforded by warm injections or by hot applications to the anus. *T. L. S.*

TENESMUS, VESICAL. Syn.: Strangury; Lat., Urinæ stillicidium; Fr., Strangurie; Ger., Harnstrenge; Gr., στραγγουρία. This is a condition in which there is an almost constant, urgent desire to urinate, the act itself being accompanied by more or less pain. The urine, which sometimes contains more or less blood, is voided in very small quantities, sometimes drop by drop, and its passage is attended with severe pain in the perineum,

groins, hypogastrium, and often, in men, in the glans penis. The pain is lancinating in character, occurring in paroxysms, and is caused by the forcible spasmodic closure of the sphincter vesicæ; it may vary from a slight uneasiness to most excruciating torture. The desire to pass water is constant and imperative, yet the patient fears to yield to it, dreading the agony which the act causes.

Strangury is a symptom of irritability of the neck of the bladder, from whatever cause, and is pathognomonic of no special disease. It is often the most prominent symptom in various bladder troubles, and is usually the one for the relief of which the patient seeks advice. It is commonly present in cystitis, tumors of the bladder, vesical calculus or gravel, acute inflammation or congestion of the kidneys, hypertrophy and other diseases of the prostate, hyperacidity or alkalinity of the urine, etc. It sometimes occurs, with rectal tenesmus, in dysentery and other inflammatory diseases of the lower bowel. It is also caused by the ingestion or absorption of certain drugs, such as cantharides and turpentine, and it is a not uncommon experience to meet with more or less strangury after the application of a large fly-blister to any part of the integument.

When a patient presents himself, complaining of this symptom, it is necessary, of course, to search for the causal affection, and to institute the treatment proper for that condition. But it is often possible to greatly mitigate the severity of the vesical tenesmus, even before a cure of the affection, to which the irritability of the neck of the bladder is due, has been obtained. The urine should be rendered as bland as possible by means of demulcent drinks and by the ingestion of large quantities of water, so as to increase its dilution. If it is highly acid the citrate or acetate of potassium, in very dilute solution, may be given frequently; and if it is alkaline, benzoic acid will serve a useful purpose. The distress may likewise be moderated by opium and belladonna suppositories, by small enemata containing laudanum, or, better, by morphine hypodermatically administered. When practicable, the continuous hot sitz-bath will be found usually to give the greatest measure of relief, the patient being instructed to pass his water in the bath. Minute doses of cantharides or turpentine sometimes afford considerable relief, especially in the vesical tenesmus dependent upon enlarged prostate. Other drugs that have been recommended are gelsemium, bromide of potassium, aconite, veratrum viride, thymol, and various antiseptics and diuretics. *T. L. S.*

TENOTOMY. The first recorded instances of tenotomy were for the cure of muscular torticollis. The operation was performed by Roonhuysen in 1670, and again by Minnius, in 1685. Thilenius is said to have divided the tendo Achillis in 1684. In all these cases the division of the tendon was accomplished through an open wound. In 1816 Delpech made the first advance in the direction of a subcutaneous operation. He made a longitudinal incision in the skin, parallel with the course of the tendon, and at a little distance from it, and then effected the division of the tendon by means of a knife introduced through the wound so made. His operation was for the division of the tendo Achillis, and six years later, in 1822, Dupuytren performed tenotomy of the sterno-cleido-mastoid by the same method. Subcutaneous tenotomy, as it is now understood, was first performed by Stromeyer in February, 1831, and it is to him that we are indebted for the operation as it is practised at the present day. To Dieffenbach, also, is due much credit for his earnest advocacy of the procedure. Dr. Little, of London, who was himself a sufferer from talipes, and was successfully treated by Stromeyer, introduced the operation into England. In this country tenotomy was first performed by Dr. David L. Rogers, of New York City, in 1834. Dr. Detmold, of the same city, Dr. Mütter, of Philadelphia, and Dr. Richardson, of Kentucky, also contributed much to the general acceptance of tenotomy by the surgeons of this country.

The operation of tenotomy is indicated whenever contracture of a muscle exists as an impediment to the reduction of deformity. It is in the treatment of club-foot, however, that the operation finds its most frequent application. It is employed also in muscular torticollis, and in contractures of the muscles concerned in movements of the hip, knee, elbow, fingers, toes, etc.; in strabismus, in spasmodic stricture of the anus, and as a preliminary to the reduction of old dislocations. It should not, however, be employed indiscriminately, but only after a careful study of the indications in each individual case, and with a thorough appreciation of what it is desired to accomplish by means of it. In bony anchylosis, for example, it is evident that tenotomy alone will be useless, though it may sometimes be useful as a preliminary to osteotomy. In the malpositions occurring during the active stage of joint disease from reflex muscular action, tenotomy will be useless, and should not be attempted. In paralytic deformities, also, division of the tendon of a healthy muscle is productive of no permanent benefit.

The sins of commission are, however, less frequent as regards tenotomy than are those of omission, and it is, perhaps, of even greater importance to know when to perform the operation than when not to perform it. The rule laid down by Sayre, of "point-pressure," as an indication for the operation is a good one. It is not, however, infallible in every sense, for, while it will be perfectly safe and necessary to operate when reflex spasm is present, yet the writer has met with cases that were benefited by tenotomy, in which he was unable to elicit the spasmodic reflex. It is possible that in these cases the muscle might have been elongated by persevering manipulations, for stretching had been tried for a short time only; but the division of the tendon did no harm and certainly expedited matters. The following is the law referred to, as given by Sayre in his lectures on "Orthopedic Surgery, and Diseases of the Joints," p. 35.


Fig. 3820. — Tenotomes.

"Place the part contracted as nearly as possible in its normal position, by means of manual tension gradually applied, and then carefully retain it in that position; while the parts are thus placed upon the stretch, make additional point-pressure with the end of the finger or thumb upon the parts thus rendered tense, and, if such additional pressure produces *reflex contractions*, that tendon, fascia, or muscle must be divided, and the *point* at which the reflex spasm is excited is the point *where* the operation should be performed. If, on the contrary, while the parts are brought into their normal position by means of manual tension gradually applied, the additional point-pressure does *not* produce reflex contractions, the deformity can be permanently overcome by means of constant elastic tension, and the more you cut the greater will be the amount of damage done. This is an important law . . . for its application . . . is universal in deciding the question of cutting contracted tissues. Even when the parts can be completely restored to their normal position by means of manual force gradually applied, if this additional point-pressure produces pain or spasm, the contractured tissue must be cut before a complete cure can be effected."

Tenotomy may be performed either by cutting down directly upon the tendon through the skin and superficial tissues, or by what is known as the subcutaneous method. The latter is practically the only one employed at the present day, so that the word tenotomy, unless some qualifying term is added, is commonly understood to mean the subcutaneous division of a tendon.

The instruments employed are short, slender knives,

called tenotomes. They may be sharp-pointed or blunt, and may have a straight, convex, or concave cutting edge (Fig. 3820). The form of tenotome used is for the most part a matter of individual preference or custom. For most operations a straight, sharp-pointed instrument will be all that is necessary, though it is well to be provided with the curved and blunt-pointed instruments, which may be required in special cases. That part of the handle which corresponds to the cutting edge should always be marked in some way, in order to prevent confusion during the operation, when the blade is buried out of sight in the tissues. The strength of the tenotome is a matter of considerable importance, for, though of small size, it is often called upon to divide very dense tissues.

The other things necessary for the operation are two or three narrow strips of adhesive plaster, a couple of small sponges or a little absorbent cotton, thoroughly sterilized, and a compress made of sublimate or iodoform gauze.

The use of ether or chloroform is not advisable, except in the case of a very timid patient, for the operation is of very short duration, and it may be rendered entirely painless, if desired, by the previous injection of a few minims of a solution of cocaine. When, however, it is proposed to perform several subcutaneous sections in a young or nervous child, it may save some time and annoyance to have the patient under the influence of an anæsthetic. Chloroform is preferable to ether in the case of a young and healthy child. Nitrous oxide gas has been suggested as a specially appropriate anæsthetic in cases of tenotomy, as it is said to cause muscular contractions. Dr. W. A. Hunt has reported, in the *British Medical Journal*, an instance in which it was necessary to suspend the exhibition of the gas in a case of tooth extraction, because of the severe pain excited in a sprained ankle by the contraction of the muscles.

The operation of subcutaneous division of a tendon is a very simple one. The services of an assistant are often of great help, yet they are not usually absolutely necessary. The patient, anæsthetized or not, as the case may be, is placed in such a position that the tendon to be divided is readily accessible, and the limb is then manipulated so as to put the tendon on the stretch. A straight, sharp-pointed tenotome, previously sterilized, is now passed flatwise beneath the tendon and as close to it as possible, so as to avoid wounding any of the adjacent tissues. The knife is then turned with the cutting edge against the tendon and the latter is divided, with a rocking or sawing motion, in a direction toward the skin. It is necessary to use great care, when the tendon is nearly severed, in order to avoid cutting through the skin, and thus making an open wound. Some surgeons prefer to make the incision through the skin first, and then to introduce a blunt-pointed instrument and complete the operation with it. This is advisable in certain cases, when important vessels or nerves in the vicinity are exposed to injury from the point of the instrument. In some situations it will be found better to divide the tendon from without inward, in order to avoid the possibility of accidentally cutting through the skin. The operator must be sure that he has severed all the fibres of the tendon, otherwise the operation will fail in accomplishing the results desired. After the tendon has been cut through, the knife is withdrawn on the flat, in the same manner in which it was introduced, the finger being pressed upon the part so as to prevent the admission of air into the wound. A small pad of sublimate gauze is now placed over the point of incision, and retained by a couple of strips of adhesive plaster.

There are several accidents which may occur during or after the operation, and they should always be borne in mind as the best means of preventing them. These are, wounding an artery or vein, division of a nerve, or of the skin above the tendon, and inflammation and suppuration at the point of division of the tendon, resulting in non-union of the separated extremities. Non-union of the divided tendon may also occur from other causes, and sometimes has taken place most unexpectedly, when all the conditions seemed most favorable.

Much has been written about the repair of tendons after subcutaneous division, but the limits of this article forbid more than a very brief description of the process. Immediately after the operation there is a separation of greater or less extent between the divided ends of the tendon, the space between them being occupied by the sheath of the tendon, into which more or less blood has been effused. In the case of the tendo Achillis, which has no true sheath, the surrounding connective tissue fills the space. In a few days there is a pouring out of lymph and corpuscles, and a new formation of embryonic tissue takes place around the ends of the tendon and, to a less extent, between them. The extremities of the tendon become bulbous and are united by a cord of newly formed tissue, which is thinnest at its centre, growing thicker as it approaches the tendon at either end. This new material is gradually converted into fibrous tissue, which is barely distinguishable from true tendon tissue. The splice is thicker and more nearly resembles the tendon, if no motion of the parts has been permitted after the operation, and if no stretching of the new tissue has been done.

It was formerly taught that the divided ends of the tendon should never be allowed to separate, after tenotomy, any farther than could be helped, the fear being that union would be imperilled if such separation should take place. Even now it is, perhaps, the rule with most surgeons to approximate the ends of the tendon by retaining the parts in the position of the original deformity for some days, until it is supposed that union has taken place. Then, by means of gradual stretching, the newly formed tissue is elongated and the deformity is little by little overcome. That the deformity may be overcome by this method the general experience of surgeons has amply proved, but the plan of immediate restoration of the parts is much to be preferred.* In this method the deformity is at once overcome as far as it may be, and the parts are retained in their new position until firm union, by means of the new material between the separated ends of the tendon, has taken place. This method has several advantages in that it gives usually a better result, the newly formed tendon is larger and stronger, and the desired result is more quickly attained and at the expense of much less suffering to the patient. Care should, of course, be taken that the deformity be not over-corrected, so as to convert, for instance, a talipes equinus into a calcaneus, as has sometimes been done. This is, however, a rare accident, and usually, if not always, a preventable one. Non-union is no more liable to occur after immediate restoration than it is when the divided ends of the tendon are approximated. When tenotomy is performed as a preliminary to the operation of forcible breaking up of anchylosis, the external wound should be allowed to heal first, as otherwise the forcible stretching might readily tear the skin and convert the subcutaneous tenotomy into an open one. The reader will find a very clear statement of the arguments in favor of this method in a paper by Dr. Reginald H. Sayre, on "The Immediate Restoration of Parts to the Normal Position after Tenotomy," read before the Orthopedic Section of the New York Academy of Medicine, May 21, 1886, and published in the *Alabama Medical and Surgical Journal* of the same year.

The following are, in brief, the rules to be followed in making subcutaneous sections of individual tendons:

STERNO-CLEIDO-MASTOID.—In dividing either the sternal or the clavicular portion the tenotome is to be inserted beneath the tendon at a short distance above its insertion, and the section is to be made toward the skin. Care must be taken not to make the incision too high up, for fear of wounding the vessels in the neck.

TRAPEZIUS.—Division of this muscle, near its origin from the superior curved line of the occipital bone, is

* Scoutetten, as early as 1838, advised immediate restoration, though in a rather timid manner. He compared stretching of the newly formed tissue to the elongating of a bar of softened glass, and maintained that increased length in such a case was obtained at the expense of thickness. His example does not seem to have been followed by other surgeons of that day.

sometimes required. This is done by inserting the knife beneath the muscle, at a short distance from the bone, and dividing it toward the skin.

BICEPS.—This muscle may be divided just above the point where the bicipital fascia is given off. The tenotome should be introduced beneath the tendon, hugging it closely, in order to avoid the brachial artery, and the section is to be made toward the integument.

EXTENSOR MUSCLES OF THE THUMB.—These tendons may be severed where they form by their prominence the "tabatière." They are to be divided from within outward, care being taken to avoid the radial artery passing along the bottom of this triangle.

EXTENSOR COMMUNIS DIGITORUM. — These tendons may be divided on the dorsum of the wrist or of the hand, by introducing the knife above them and cutting down upon the bone. Of course, they should not be cut at the points where they pass over the joints.

FLEXORES CARPI.—Both the radial and the ulnar flexors have their corresponding arteries to the outer side, and the tenotome should be passed between the tendon and the artery, the edge turned away from the latter, and the tendon divided toward the integument.

FLEXORES DIGITORUM.—These tendons seldom require division, and as the operation is apt to be followed by severe inflammatory reaction it is better to avoid their section, if possible. They may be severed by introducing the knife between them and the integument and cutting down upon the bone beneath.

TENSOR VAGINÆ FEMORIS.—In the division of this muscle the knife may be introduced on either side of it, a short distance below its origin from the crest of the ilium, the section being made toward the integument.

SARTORIUS.—The knife is passed beneath the muscle, from its inner side, about two inches below the anterior superior spinous process of the ilium, and the division is made in an outward direction.

PECTINEUS.—Division is best made in a direction downward and inward, in order to avoid injury to the femoral vessels. The tenotome should be introduced at the outer edge of the muscle, about an inch from its origin.

ADDUCTOR LONGUS.—The knife is to be passed beneath the muscle, at its outer edge, a short distance below the pubes, and the division is to be made toward the integument.

QUADRICEPS EXTENSOR FEMORIS.—The tendon of this muscle can be divided a short distance above the patella, by an incision made from without inward. Some care is necessary to avoid opening the synovial sac of the knee-joint, which extends up under the tendon at this point.

HAMSTRING TENDONS.—The outer hamstring tendon is in close relation on its inner border with the external popliteal nerve. The knife should be passed between the tendon and the nerve, and the division made from within outward and toward the integument.

The inner hamstring tendons are, in their order from the inner side of the knee to the median line of the popliteal space, the sartorius, gracilis, semi-membranosus, and semi-tendinosus. The two latter are the ones that most frequently require division. Either or all of these tendons can be divided by the knife introduced at the inner side, and directed outward and toward the skin.

TENDO ACHILLIS.—The patient is placed in the prone position, an assistant flexing the foot strongly, so as to put the tendon on the stretch, and the tenotome is then introduced from the inner side, and close to the tendon, so as to avoid wounding the posterior tibial artery. The division is made toward the skin, care being taken that this is not wounded when the last fibres of the tendon are severed.

TIBIALIS ANTICUS.—The knife should be inserted on the outer side of the tendon, just in front of the internal malleolus, the division being made from without inward and toward the skin.

TIBIALIS POSTICUS.—The division of this tendon may be made in the leg or in the foot, the latter being more difficult, however, especially in young children. If the division is to be made in the leg, the child should be placed so that the foot rests on its external border. The tenotome is introduced a little less than an inch above the internal malleolus, and about midway between the malleolus and the border of the tendo Achillis, and the division is made from below upward toward the skin. If the incision is made too near the malleolus, there will be danger of wounding the internal saphenous nerve or vein, and if it is made too near the tendo Achillis, the flexor longus digitorum, the posterior tibial artery, or the posterior tibial nerve will be liable to be severed. In order to avoid these structures it has been proposed to divide the tendon in the foot. This may be done in a line drawn from the tip of the internal malleolus to the scaphoid bone, a short distance below and in front of the malleolus. There would seem, however, to be no special advantages in this procedure, and in children it is very difficult to make the section in the foot.

PERONEUS LONGUS.—The knife is to be introduced a short distance above the external malleolus, where the tendinous cord can usually be felt, and the section is made from behind forward and toward the skin.

PERONEUS BREVIS.—The tendon of this muscle lies just above and behind that of the long peroneal muscle. It may be divided at the same time that the section of the long peroneal is made. If, however, it is desired to sever it alone, the operation should be done in the foot. The tendon will be found in a line drawn from the posterior border of the external malleolus to the posterior extremity of the fifth metatarsal bone, from one-half to one inch in front of the malleolus. The peroneal tendons seldom require section, and it must be very rare indeed that one is to be divided without the other.

FLEXOR LONGUS POLLICIS.—This tendon may be divided at its most prominent part on the inner border of the foot. Care must be observed to avoid the internal plantar artery which runs along the inner border of the tendon.

FLEXOR LONGUS DIGITORUM.—The tendon of this muscle lies just behind that of the posterior tibial. The two tendons are usually divided simultaneously, but they may, with some care, be severed separately if it be desired. In division of this tendon great care will be required to avoid the posterior tibial vessels. These should, if possible, be pushed toward the tendo Achillis, and the knife may be introduced between the vessels (held out of the way by the finger) and the tendons of the posterior tibial and flexor longus digitorum muscles, a blunt-pointed instrument being used after the primary incision has been made through the skin; the flexor tendon is then carefully severed in a direction toward the integument. Parker advises the division of the tendon of this muscle, together with that of the posterior tibial, in the sole of the foot, just below the astragalo-scaphoid articulation, at a point where they cross each other.

These are the chief muscles that require tenotomy, excepting those of the eye; and for a description of the operations in this region the reader may consult the article on Strabismus in this volume of the HANDBOOK.

APONEUROTOMY, or fasciotomy, as it has been barbarously called, is the division, usually subcutaneous, of an aponeurosis, generally the palmar or plantar.

Palmar aponeurotomy, as proposed by Adams in the treatment of Dupuytren's contraction, consists of multiple subcutaneous sections of the fascia made at different points along the ridges caused by the contractured tissue. The knife, which should be small though strong, is to be introduced between the fascia and the skin, and the former divided from the surface downward. The sections are to be repeated at various points, until the bent finger can be straightened. As soon as the knife is withdrawn from the wound, the opening should be covered with a piece of plaster, a wad of antiseptic gauze, or something of the sort, before the next incision is made. Some care is necessary at times to avoid wounding the sheaths of the extensor tendons, an accident that is liable to be followed by considerable inflammation, in spite of the most thorough antiseptic precautions.

Plantar Fascia.—The division of this tissue is very frequently demanded in the treatment of club-foot. It

may be made at any point where the structure is most prominent, by introducing a tenotome beneath it, in the usual manner, flatwise, and cutting toward the skin.

MYOTOMY is the term employed to denote a subcutaneous section of the belly of a muscle instead of that of its tendon. It is very seldom performed, tenotomy being usually more convenient and much simpler. The same precautions against the admission of air and the wounding of neighboring structures are, of course, to be observed in myotomy as in tenotomy.

SYNDESMOTOMY, or the subcutaneous division of ligaments, is employed not uncommonly in the reduction of old dislocations in cases in which these structures offer very obstinate resistance to the replacement of the luxated bone. Syndesmotomy is advised and practised by Parker in the treatment of many cases of congenital talipes. He believes that the failures after tenotomy are often due to the fact that the ligaments are shortened, and do not yield sufficiently to allow of perfect reduction of the deformity. The subcutaneous division of ligaments is performed in the same manner and with the same precautions as that of tendons or muscles. It is necessary, however, to observe special care as regards antisepsis, since the joint is opened, and consequently very severe inflammation may follow the operation when carelessly performed.

The reader desiring more detailed accounts of the different subjects touched upon in this article may consult the following works, which are but a few among the more important of the many published:

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Brodhurst, B.: Orthopædic Surgery. London, 1876.
Sayre, L. A.: Orthopædic Surgery and Diseases of the Joints. New York, 1883.
Parker, R. W.: Congenital Club-foot, its Nature and Treatment. London, 1887.

Thomas L. Stedman.

TEPLITZ-SCHÖNAU is a well-known and popular health-resort, lying in a pleasant and well-protected valley, in Bohemia, at an elevation of about 700 feet above sea-level. The climate is rather mild, but there are apt to be sudden changes of temperature. There are eleven thermal springs at Teplitz, the waters of which contain a rather large proportion of mineral ingredients. The following is the analysis of the water. One litre contains:

	Gramme.
Potassium sulphate	0.017
Sodium sulphate	0.079
Sodium chloride	0.066
Sodium carbonate	0.403
Magnesium carbonate	0.013
Calcium carbonate	0.057
Silicic acid	0.046
Organic matters, etc	0.007
Total	0.688

The temperature of the different springs varies between 82° and 118° F.

The waters are employed externally only. Other therapeutic measures in use are mud-baths and the drinking of imported mineral waters.

The indications for the warm baths of Teplitz are gout and chronic articular and muscular rheumatism, neuralgia, various forms of skin disease, etc. The season extends from May to October, but many visit Teplitz even during the winter months. *T. L. S.*

END OF VOLUME VI.